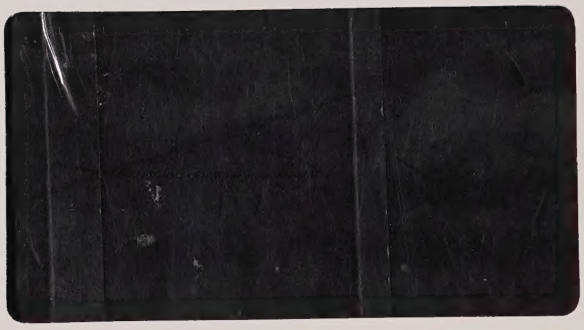
INSTRUCTION MANUAL

MODEL 740
PHASE METER

WAVETEK

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA



Serial No. _____

INSTRUCTION MANUAL

MODEL 740
PHASE METER

WAVETEK
Box 651, San Diego, Calif., 714-279-2200

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WARRANTY

All Wavetek instruments are warranteed against defects in material and workmanship for a period of one year after date of manufacture. Wavetek agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during this period. Wavetek's obligation under this warranty is limited solely to repairing any such instrument which in Wavetek's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by purchaser. Shipment should not be made without prior authorization by Wavetek.

This warranty does not apply to any products repaired or altered by persons not authorized by Wavetek, or not in accordance with instructions furnished by Wavetek. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

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Product Improvement Notice

Wavetek maintains a continuing program to make improvements to their instruments that will take advantage of the latest electronic developments in circuitry and components.

Due to the time required to document and print instruction manuals, it is not always possible to incorporate these changes in the manual.

Wavetek has manufactured your instrument, using metal film 1% tolerance resistors in place of 5% carbon resistors, wherever practical. This results in a substantial improvement in the overall performance of your instrument. Therefore, there may exist a discrepancy between the resistor used to manufacture your instrument and the resistor called out in the Parts List and Schematic Diagrams in this manual.

If field replacement of an affected resistor does become necessary, replacement may be made in accordance with the manual call outs. Wavetek, however, recommends replacement with the same type of resistor used in the manufacture of your instrument, whenever possible.

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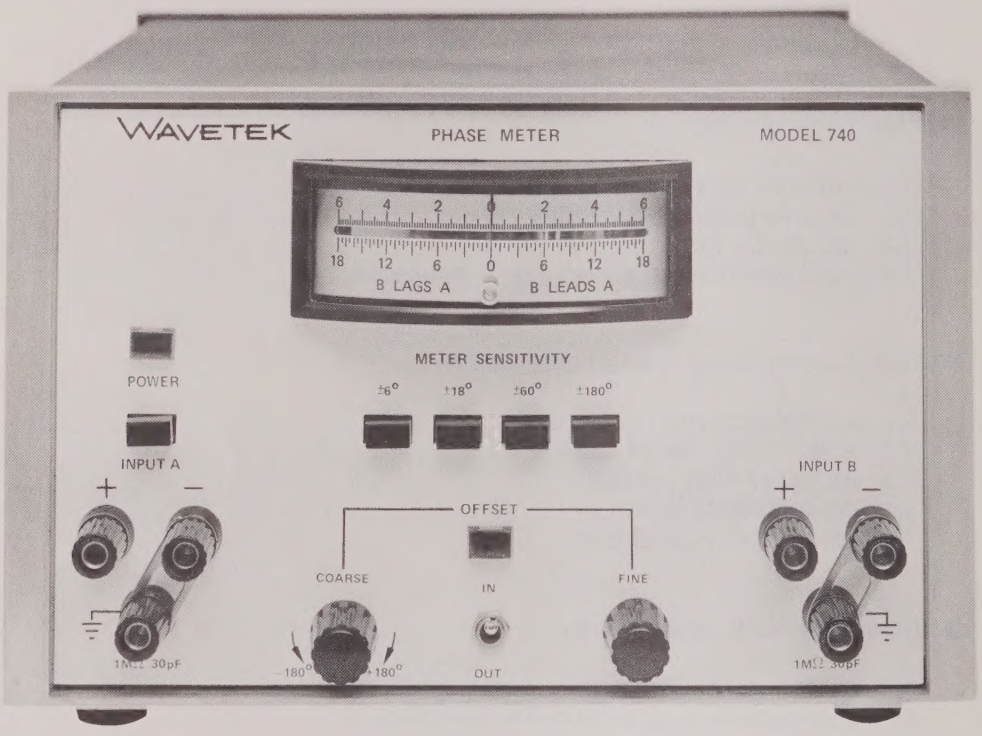


Figure i. Model 740 Phase Meter

SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of the WAVETEK Model 740 Phase Meter.

SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The WAVETEK MODEL 740 PHASE METER has been designed to accurately measure the phase angle between any two ac signals (with an amplitude dynamic range as great as 2000 to 1) within the 10 Hz to 2 MHz range. A precision wideband bench instrument, the Model 740 uses a unique circuit design which permits accurate phase angle measurements with input signals having high even harmonic distortion. A meter with offset capabilities is used to display the phase angle being measured to within 0.1° resolution.

Four ranges (±180°, ±60°, ±18°, and ±6°) allow selection for maximum sensitivity. High impedance differential inputs are used; and a dc OUTPUT −10mV/DEG is provided for use in recording phase angle measurements, or as a control signal for phase lock loops or servo systems. The output is displayed, in degrees and tenths of degrees, directly on a digital voltmeter.

The automatic operation of this instrument eliminates the need for amplitude matching, frequency tuning, and output filtering, resulting in true hands-off operation.

1.2 GENERAL PHYSICAL DESCRIPTION

Weighing approximately 9 pounds (11 pounds when shipped) the Model 740 is 8-1/2 inches wide, 5-1/4 inches high, and 10-1/2 inches deep. Housed in a compact, ruggedized, portable case; the Model 740 is normally shipped with a 10-foot, 3-wire, detachable line cord and one copy of this instruction manual.

1.3 SPECIFICATIONS

1.3.1 Power Requirements

100-130 Vac or 200-260 Vac, 50-400 Hz, less than 25 W, single phase.

1.3.2 Input Signals

Frequency Range . . . . . 10 Hz to 2 MHz

Amplitude Range	Limit
50 mV-50 VOLTS RMS	500 Vdc

Input Impedance
Single-Ended Inputs . . . . . 1 MΩ, shunted by 30 pF
Differential Inputs . . . . . 2 MΩ, shunted by 20 pF

Common Mode Rejection
10 Hz to 100 kHz . . . . . Greater than 50 dB
100 kHz to 2 MHz . . . . . Greater than 40 dB

1.3.3 Output Signals

OUTPUT −10mV/DEG (Standard)
Amplitude . . . . . +1.8 Vdc to −1.8 Vdc
Output Impedance . . . . . 1 kΩ

1.3.4 Accuracy

Absolute Calibration Accuracy
20 Hz to 20 kHz square wave, 100 mV to 5 V p-p . . . ±0.1°

Frequency Effect on Accuracy (100% of Range Sine Wave Inputs)
20 Hz to 20 kHz . . . . . Calibration Accuracy ±.2°
Zero Offset, 10 Hz to 10 kHz . . . . . Less than 0.1°
Zero Offset, 10 kHz to 100 kHz . . Less than 0.1°/10 kHz
Relative Accuracy, 100 kHz to 2 MHz . . . . Better than 2°

Amplitude Effects on Accuracy
Less than 1.5° for 60 dB change on both inputs.
NOTE: Minimum sensitivity below 20 Hz and above 50 kHz is 1% of amplitude range.

Phase Angle Resolution . . . . . 0.1°

Phase Angle Drift . . . . . Less than .2°/8 hours

Response Time (Full Scale Change) . . Less than 4 seconds

NOTES

1. *A faster response time may be ordered (as an option) for measuring fast changing phase angles.*
2. *Phase angle measurements within 2° of the RANGE limits should be avoided; allow ±5° for frequencies below 50 Hz.*
3. *The instrument is designed for use with Tektronix or Hewlett Packard 10X probes.*

1.3.5 Mechanical Characteristics

Dimensions and Weight

Width . . . . . 8-1/2 inches
Height . . . . . 5-1/4 inches
Depth . . . . . 10-1/2 inches
Weight (Nominal) . . . . . 9 pounds
Weight (Shipping) . . . . . 11 pounds

Connector Types

Inputs . . . . . 3 Binding Posts, 3/4-inch spacing
Output . . . . . 2 Binding Posts, 3/4-inch spacing

1.3.6 Environmental Characteristics

Recommended Warmup 1/2-hour

Operating Temperature Range . . . . . 25°C (±5°C)

1.4 ACCESSORIES AND ASSOCIATED EQUIPMENT

The Model 740 is normally shipped with a 10-foot, 3-wire, detachable line cord and a copy of this instruction manual. The items listed below are compatible accessories and associated equipment which may be helpful in the user's installation.

Rack Adapter Kit . . . . . Wavetek No. 130-602

Attenuators, 10 to 1 . . . . . Dual Banana Jack Output
Single BNC Output

Adapters, Dual Banana . . . . . Dual Banana to BNC Plug
Dual Banana to BNC Receptacle

Shielded Test Leads, 36-inch . . Dual Banana to Dual Banana
Dual Banana to Alligator
Dual Banana to BNC

All phase angle measurements are dependent on type of waveform, amplitude, and frequency. The diagrams below show the absolute accuracy, taking into account all sources of error.

ABSOLUTE ACCURACY
100 Hz-100 kHz

ALL ACCURACIES STATED ARE ± DEGREES

CHANNEL A AMPLITUDE PERCENT OF FULL SCALE	.1%	1%	10%	100%
100%	2.4	1.5	0.7	0.4
10%	1.5	0.7	0.6	0.7
1%	0.7	1.0	0.7	1.5
.1%	1.5	0.7	1.5	2.4

CHANNEL B AMPLITUDE
PERCENT OF FULL SCALE

MULTIPLICATION FACTOR
AS A FUNCTION OF FREQUENCY

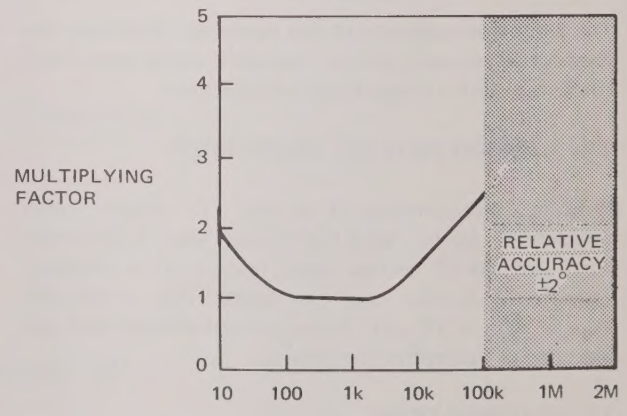


Figure 1-1. Instrument Accuracy Diagrams

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect the external parts for damage to knobs, indicators, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

No mechanical installation is required when the instrument is to be used as a portable bench unit. If a rack mounting configuration, or a Rack Adapter Kit (see paragraph 1.4), is provided; the unit may be mounted in a standard 19-inch equipment rack. Instructions for attaching the Rack Adapter Kit are provided with the kit.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit and the ac line supply. Check that the proper type of fuse is installed for the line supply being used.

NOTE

Unless otherwise specified at the time of purchase, the Model 740 is shipped from the factory with the power transformer connected for operation on a nominal 115-volt ac line supply. Conversion for 230-volt operation requires resetting a switch at the rear of the unit. To reset the 115/230 conversion switch (concealed by the rear panel) remove the rear panel, set the switch to 230 using a thin-bladed screwdriver, and replace the panel. Install a 1/8-ampere fuse in place of the normal 1/4-ampere fuse.

2.2.2 Input Connections

Connect the desired input signals to their respective connectors using shielded cable equipped with dual banana connectors. Connect single-ended inputs between ground and the appropriate polarity terminal, with the shorting link connected between ground and the opposite polarity terminal. Connect differential inputs between the "+" and "–" terminals, and disconnect the shorting link. See Table 2-1 for input connections and their requirements.

Table 2-1. ELECTRICAL INSTALLATION GUIDE

Symbol	Name	Function
J1	(Line Cord)	Connector for 3-wire line cord.
J2	INPUT A "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground. Observe amplitude specifications and limits of paragraph 1.3.2. Use shielded cables with dual banana connectors for these connections.
J3	INPUT A "–"	
J4	INPUT A "⏚"	
J5	INPUT B "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground.
J6	INPUT B "–"	
J7	INPUT B "⏚"	
J8	OUTPUT –10mV/DEG	Standard output connector.
J9	(Output "⏚")	

2.2.3 Output Connections

Connect the OUTPUT −10mV/DEG to the desired point. Since the OUTPUT −10mV/DEG has an output impedance of 1 kΩ, loading of this output must be considered. This output is short circuit proof and shorting it will not inhibit normal operation. See Table 2-1 for output connections and their requirements.

2.3 INSTALLATION CHECKS

This paragraph outlines a quick checkout procedure for determining proper operation of the instrument. Field calibration and checkout instructions are given in Section 4 for determining if the unit is within all electrical specifications. See Table 2-2 for a description of the functions of the operating controls. No special test equipment is required to perform a checkout of the instrument as outlined below.

1. Connect the line cord to the instrument and the line supply, depress POWER pushbutton, and allow a 20-minute warmup period for the unit to reach a stable operating temperature.
2. Hold CALIBRATE switch (on the rear panel) in the +180.0 position. The meter should display 180°, B lags A.
3. Hold CALIBRATE switch in the −180.0 position. The meter should display 180°, B leads A.

If, after sufficient warmup, the proper readings are not observed, refer to the Calibration Instructions given in paragraph 4.2 of this manual.

2.4 OPERATING CONTROLS

The operating controls and the functions they perform are given in Table 2-2. Additional adjustments, and the functions they perform, are described as they appear in the text of Section 3 and Section 4 of this manual. Do not disturb any control settings, with the exception of operating controls, unless absolutely necessary; and then only if suitable equipment is available for recalibration.

If the equipment appears to operate abnormally, refer to the Calibration Instructions (paragraph 4.2) and the Corrective Maintenance (paragraph 4.3) instructions.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial Installation Checks given in paragraph 2.3 of this manual.

C A U T I O N

If single-ended ac inputs are used, the shorting link must be connected between the negative and ground terminals. If differential ac inputs are used, the shorting link must be removed and the input signal must be connected between the positive and negative (+ and −) terminals.

C A U T I O N

To measure the phase angle between any two ac signals (with an amplitude ratio as great as 1,000 to 1) within the specified frequency range, proceed as follows:

Table 2-2. OPERATING CONTROL FUNCTIONS

Symbol	Name	Function
SW1	POWER	Connects ac line voltage to the instrument.
SW2	115/230	Selector for 115-volt or 230-volt operation.
SW6	CALIBRATE	Used as quick check to determine effect, if any, in phase reading.
SW5D	180° RANGE	Selects meter sensitivity of 180° full scale.
SW5C	60° RANGE	Selects meter sensitivity of 60° full scale.
SW5B	18° RANGE	Selects meter sensitivity of 18° full scale.
SW5A	6° RANGE	Selects meter sensitivity of 6° full scale.
SW3	OFFSET I/O	When set to IN, OFFSET may adjust meter.
R101	FINE	Deflects meter ±5°.
R102	COARSE	Deflects meter ±180°.

1. Depress the appropriate RANGE pushbutton to select the range (±180°, ±60°, ±18°, or ±6°) that provides the maximum resolution of phase angle, or use maximum sensitivity (±6°) with OFFSET to obtain 0.1° resolution.
2. Connect one ac signal to INPUT A terminals and the other signal to INPUT B terminals observing the CAUTION notice above.
3. Read phase angle (phase difference) directly on meter. If the meter pointer is to the right of zero, INPUT B leads INPUT A by the measured number of degrees. If the meter pointer is to the left of zero, INPUT B lags INPUT A by the measured amount.
4. OUTPUT −10mV/DEG provides the same data, electronically, for use as a control signal or for general recording applications. The instrument will display the phase angle in degrees and tenths of degrees, when applied to a digital voltmeter.
5. To operate OFFSET:
   A. Set OFFSET switch to IN and, if pointer is far to the right, rotate COARSE control counterclockwise until the pointer is close to zero. If pointer is far left, rotate COARSE control clockwise until pointer is close to zero.
   B. Select METER SENSITIVITY desired, and adjust FINE control for a pointer indication of zero.
   C. For an accurate offset adjustment, connect a digital voltmeter to the dc output and measure the phase angle when the OFFSET switch is set to OUT. Then with toggle to IN position, adjust OFFSET as in steps A and B above. Note change in digital voltmeter reading for precise amount of phase offset on meter.

SECTION 3
CIRCUIT DESCRIPTION

3.1 SIMPLIFIED BLOCK DIAGRAM

As shown in Figure 3-1, the Model 740 Phase Meter consists of two similar input channels and a common output channel. Paragraph 3.2 provides further descriptions of the functions of each basic circuit comprising this instrument. This paragraph describes, briefly, the major circuit elements and their relationship to one another.

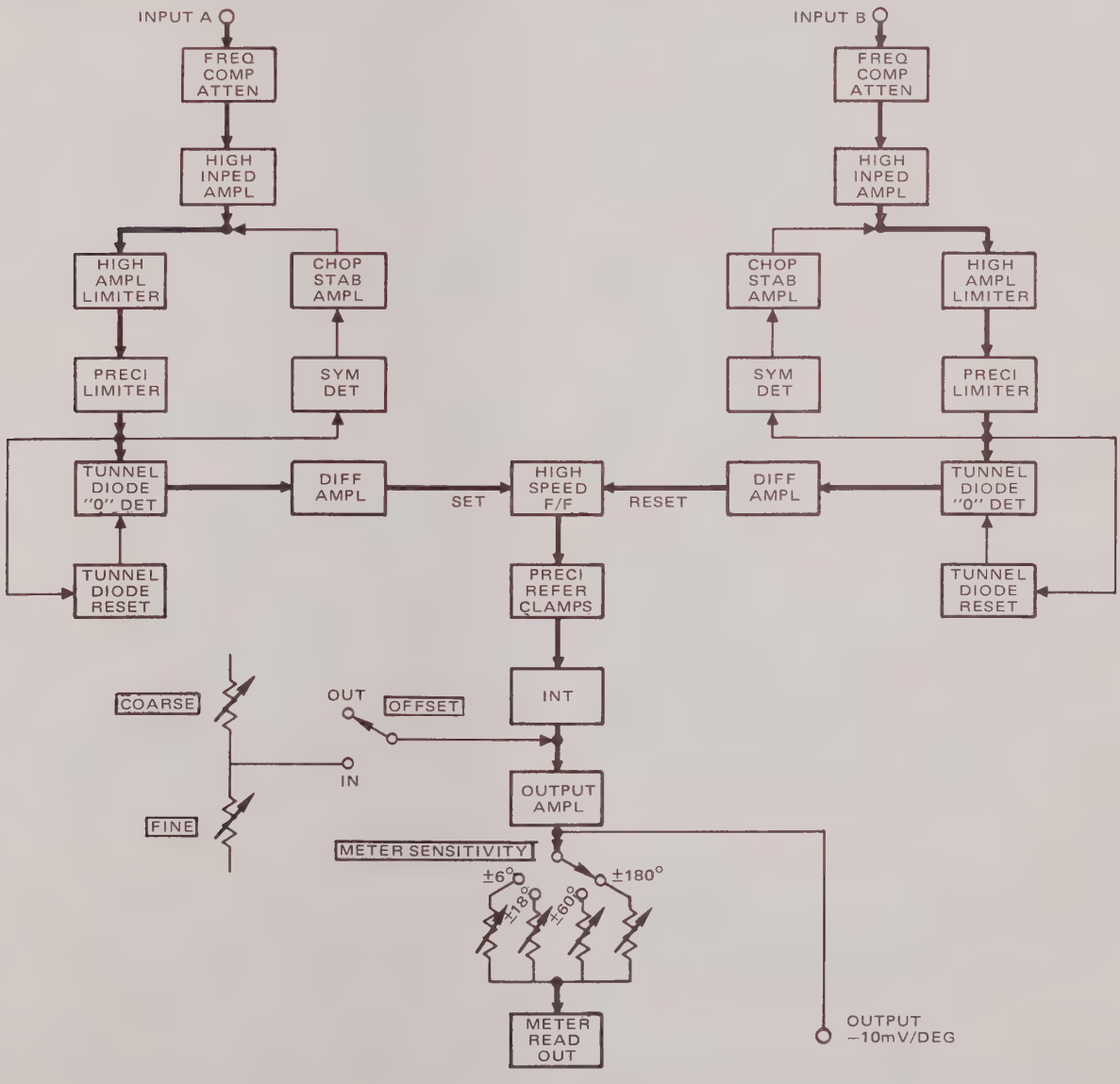


Figure 3-1. Simplified Block Diagram

The Frequency Compensated Attenuator in each input channel is used to reduce high amplitude inputs to a level suitable for the remaining circuitry. The input signal is applied to a High Impedance Amplifier stage, whose function is to isolate the plus and minus inputs and provide high common mode rejection.

Next, the signal is high-amplitude-limited to prevent overdriving in the Precision Limiter stage. The Precision Limiter is a nonlinear feedback, wideband amplifier which limits the input signal at ±5 mV. The limited output signal is applied to a Symmetry Detector which integrates the waveform and produces a dc voltage that is proportional to the symmetry of the clipped waveform. This dc output represents an error in the zero-crossing system or an error due to the distortion of the input signal. The dc level is amplified and inverted in a Chopper Stabilized Amplifier and summed at the input to the first limiter stage. The closed-loop circuitry provides long-term, stable phase detection and automatically balances the limiters to correct for drift or offset voltages in the system due to temperature variations or component aging. Errors due to even-harmonic distortion are essentially eliminated by this self-balancing zero-crossing technique.

Following the limiters, the waveform zero-crossing is detected in a wideband Tunnel Diode Zero Detector. The Tunnel Diode Reset supplies the reset signal to the detector and provides system noise immunity. The detected zero-crossing output is then applied to the High Speed Flip-Flop through a Differentiating Amplifier. The output of Channel A is applied to the "set" input, and the output of Channel B is applied to the "reset" input of the flip-flop.

The flip-flop output is applied to a Precision Reference Clamp stage which provides a signal having an amplitude defined by the reference voltage and a duty cycle proportional to the phase difference between the two input signals. This output is integrated into a dc voltage proportional to the phase difference and is applied to the Output Amplifier for full scale and zero adjustment. The OFFSET is also summed in the Output Amplifier, the output of which is then applied to the output connector and to the range switches of METER SENSITIVITY.

3.2 FUNCTIONAL BLOCK DIAGRAM ANALYSIS

As each functional circuit is described, refer to the appropriate block diagram and, if necessary, the appropriate portions of the schematic diagrams at the rear of this manual.

3.2.1 Zero Crossing Circuit (Figure 3-2 and 3-3)

Both input channels employ similar Zero Crossing Circuits. In view of this, only the functions of Channel A are described, realizing that there are counterparts in Channel B. Figure 3-2 is a functional block diagram of the Zero Crossing Circuit, Figure 3-3 shows key waveforms within this circuit.

The input signal is passed through the Frequency Compensated Attenuator before being applied to Q1-Q2, the High Impedance Differential Amplifier stage. The plus and minus inputs are symmetrically attenuated in the ac/dc attenuator which is adjusted for a flat frequency response by trimmer capacitors C1 and C5.

The input source currents for the High Impedance Differential Amplifier stage are balanced by trimmer adjust R187 to yield rejection. The output of Q1-Q2 is applied to the positive input of Input Amplifier IC1.

Trimmer capacitors C10 and C11 adjust the phase shift of the negative and positive inputs to IC1 to match those of IC4 in Channel B for best high frequency performance. IC1 provides a 180° phase shift. The gain of IC1 is near unity, and its output is applied to the summing junction at the gate of Q3. FET Q3 and transistor Q4 provide a high input impedance to the summing point, as well as temperature compensation. The output from Q3-Q4 is applied to the symmetrical Amplitude Limiter CR1-CR4. R21 is used to balance this four-diode limiter.

The output from CR1-CR4 is coupled to Precision Limiting Amplifier IC2, a 50 MHz amplifier with nonlinear feedback. R28 is a dc balance adjustment, C22 is a phase matching trimmer. The output of IC2 is a clipped waveform having an amplified volts/second relationship at the zero crossing of the input waveform.

For high accuracy, the output of the final limiting amplifier of a zero crossing system must be symmetrical for a sine wave input. To ensure this, the output waveshape must be sampled periodically and the result fed back to the input of the first limiter to correct any unbalance or dissymmetry. The Integrator (comprised of R37-R40 and C26 and C30) supplies a dc voltage proportional to the symmetry of the output of IC2 to the input of Chopper Amplifier IC3. Shunt Chopper Q11 converts the dc output of the Integrator to an ac signal. R64 is the chopper balance adjust.

This ac signal is then amplified in IC3, and the output is demodulated in Series Chopper Q13. The voltage developed across capacitor C59 is an amplified error signal proportional to the nonsymmetry of the output of IC2. This error signal is applied, through R23, to the summing point at the gate of Q3. R82 is a symmetry adjustment which controls the amount of error signal in the feedback loop. This chopper-stabilized symmetry-detection system also elimi-

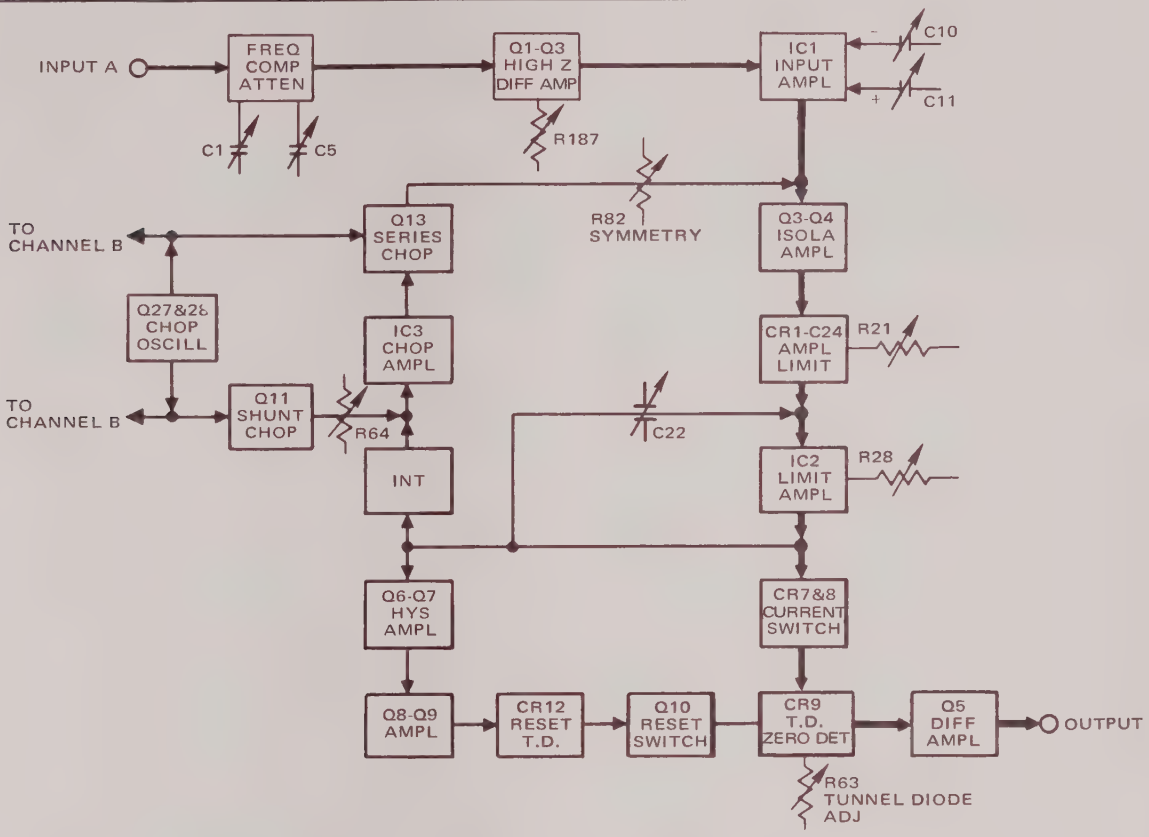
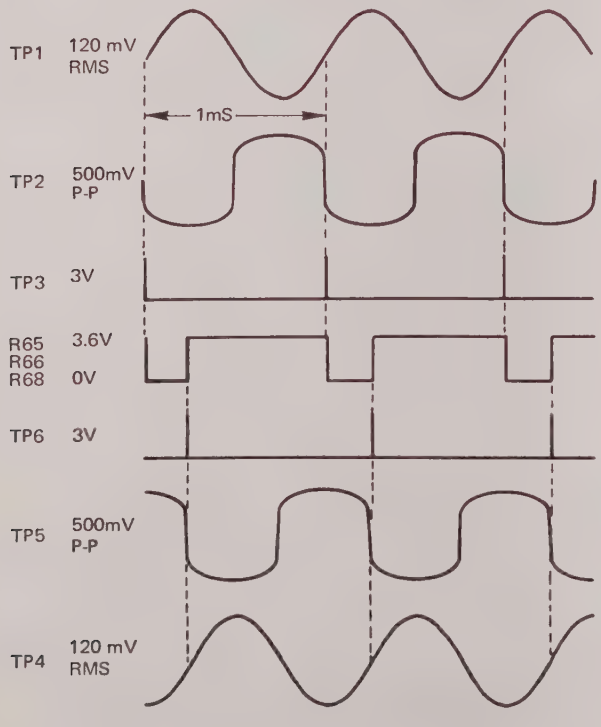


Figure 3-2. Zero Crossing Circuit, Functional Block Diagram



NOTES

INPUTS 100 mV RMS ∿

CHANNEL B LAGS BY 90°

Figure 3-3.
Timing Diagram, Zero Crossing, and Logic Circuit

nates the effects of even harmonic distortion within the limits of the chopper loop.

The symmetrical output of IC2 is then applied to Current Switch CR7-CR8 which supplies a small amount of current, at the actual zero crossing point, to trigger Tunnel Diode Zero Detector CR9. Tunnel Diode Adjust R63 sets the firing point of CR9 to be at the zero crossing point.

Differentiating Amplifier Q5 then supplies a pulse output which occurs at the true zero crossing point of the input waveform.

The reset circuitry for CR9 consists of transistors Q6 through Q10. Hysteresis Amplifier Q6-Q7 amplifies the output of IC2 and provides the necessary hysteresis to prevent double triggering. The output from Q6-Q7 is applied, through Amplifier Q8-Q9, to reset Tunnel Diode CR12. When CR12 fires, the resultant waveform drives Reset Switch Q10 to saturation which, in turn, resets the Tunnel Diode Zero Detector CR9 to its original state.

Chopper Oscillator Q27-Q28 is the circuitry common to both channels of the Zero Crossing Circuit. This oscillator supplies the chopper pulse which drives the gates of field-effect-transistors Q11 and Q13 at the proper sample rate.

3.2.2 Logic Circuit (Figure 3-3 and 3-4)

The Logic Circuit converts the pulse information generated by the Zero Crossing Circuit into a precision, linear dc voltage whose value is a direct function of the phase difference between inputs A and B.

The two pulses generated by the Zero Crossing Circuit are applied to the inputs of a fast rise and fall time Set-Reset Toggle IC4. This stage is a dual transistor gate connected as an RS toggle with hot carrier diodes CR13 and CR14 providing nonsaturated, high speed operation. This stage converts the pulse information into a rectangular waveform that drives Saturated Switch Q18-Q19.

When the CALIBRATE switch is actuated, it inhibits either the "A" or "B" input from the Zero Crossing Circuit. With one input inhibited, the Set-Reset Toggle IC4 will go to a single state and remain. One state of IC4 corresponds to -180°, the other state corresponds to $+180^{\circ}$. Therefore, when CALIBRATE switch SW6 is actuated, all dc calibrations may be checked.

Q18-Q19 operates as a pair of saturated switches between ground and a precision +3.6 Vdc. The resulting output, at the junction of R65 and R66, is integrated in Integrator R68/C24 and then filtered by an active Unity Gain Filter

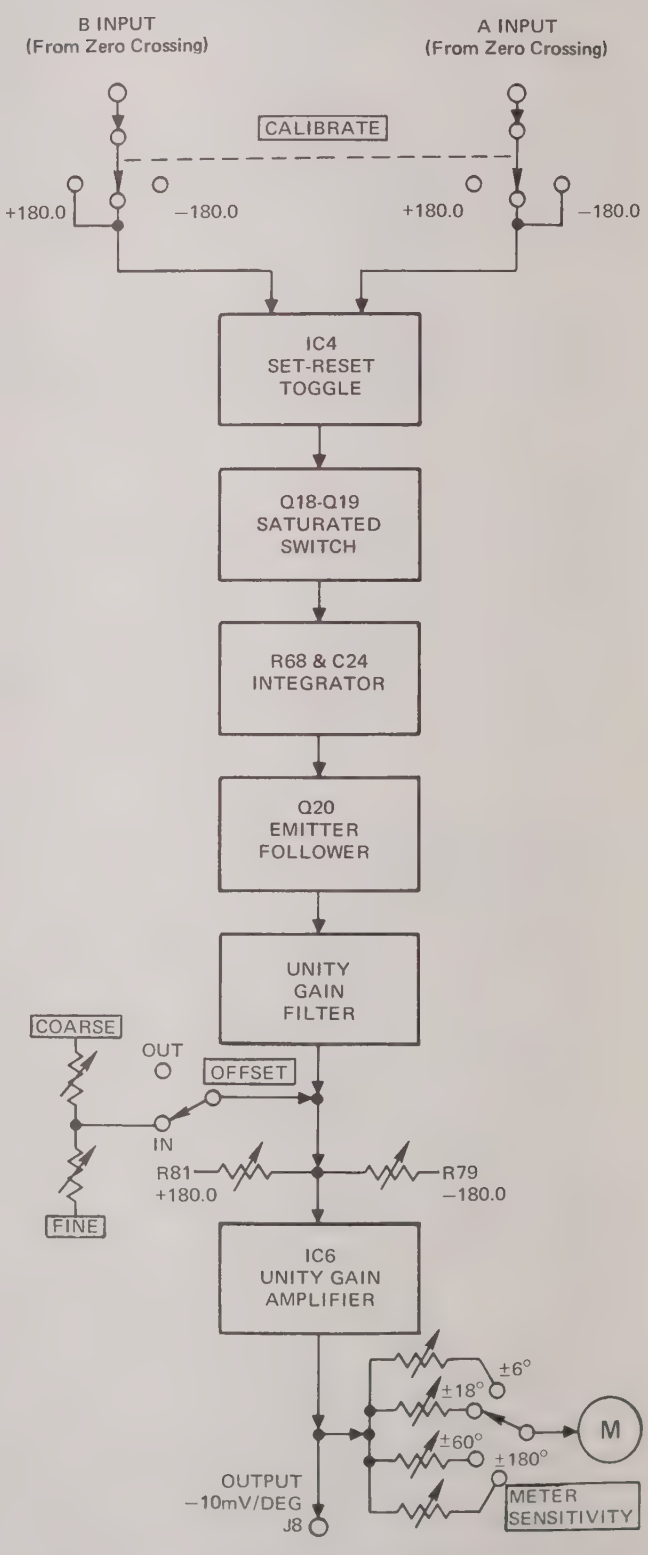


Figure 3.4. Logic Circuit, Functional Block Diagram

comprised of IC5, R69, R70, C25, and C26. Q20 functions as an Emitter Follower input to the Unity Gain Filter.

The integrated and filtered signal, representing the phase angle between INPUT A and INPUT B, is then conditioned in the Unity Gain Amplifier IC6. The final dc voltage out of IC6 has a −10 mV/degree relationship to the measured phase angle, and is provided (at J8) as an output as well as the input to the meter. The phase offset is summed in IC6 and, hence, may be used to offset the phase back to zero for use with maximum meter sensitivity.

Range calibration is accomplished by two potentiometers at the rear of the unit. The +180.0 and the −180.0 limits may be calibrated using R79 and R81 respectively.

3.2.3 DC Power Supplies (Figure 3-5)

Regulated operating voltages for the Model 740 Phase Meter include +15 V, −15 V, +3.6 V, and −3.6 V. Ac line voltage is connected through the line cord to the POWER switch on the front panel. A slo-blo fuse is installed on the line side of the switch, and a 115/230 power selector switch connects the primary winding of the power transformer for the appropriate line voltage.

Ac voltage is coupled from the transformer secondary to the Bridge Rectifier CR1-CR4. Filtering is provided by C3 and C11. Q12 is operated as a Zener diode reference voltage for the −15 V supply. IC3 is a comparator differential amplifier. The Comparator drives a Darlington-connected Series Pass transistor pair, Q9 and Q11, used for added current gain. Q8 is also connected to operate as a Zener diode reference to provide a voltage level shift for the output of IC3. R36, −15 V ADJ, adjusts the minus input of IC3 with respect to the plus input which has a Zener voltage of approximately 7 volts. If the −15 V tries to increase due to a change in line voltage or load current, the collector of Q12 stays approximately at the same voltage. Thus, the minus input to IC3 becomes more positive than the plus input, and the IC3 output draws more current. The output moves less positive, and this change is coupled to the base of Q9 and Q11 through Q8, returning the supply to −15 volts.

IC1 is a Comparator Differential Amplifier in the +15 V supply. The plus input of IC1 is returned to ground through R9. Voltage Divider R7-R8, between the plus and minus 15-volt supplies, sets the minus input of IC1 precisely at ground. An increase in the −15 volts, due to line voltage variation or load current change, results in the minus input of IC1 moving positive, and the output of IC1 moving negative. This change is coupled to the bases of Q1 and Q2 through Q4. Q1 and Q2 form a Darlington-connected Series Pass pair for added current gain. The negative-going change returns the output to +15 volts.

Q3, in conjunction with R2 through R4, comprises a foldback current limiter for the +15 V regulator. Normally, the base of Q3 is turned off. Thus, the base of Q2 moves freely as the output from IC1 changes. When the +15 volt output is overloaded, heavy current flows through R2 and creates a potential drop across the resistor. When the potential drop overcomes the drop across R3, Q3 begins to

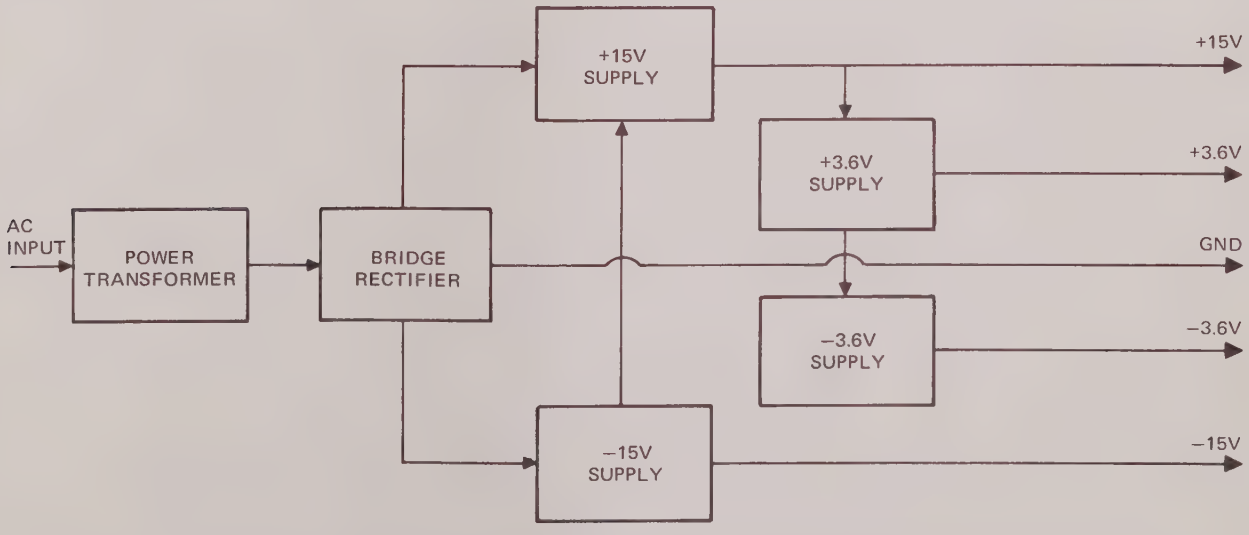


Figure 3-5. DC Power Supplies, Functional Block Diagram

conduct, starting to short the base of Q2 to the +15 volt output. In this condition, the output can be shorted indefinitely at a lower than maximum power dissipation of Q1. When the overload condition is removed from the +15 V output, the base of Q2 starts to rise. As the emitter of Q1 rises toward +15 volts, Voltage Divider R3-R4 has more effect on the base of Q3 and eventually turns Q3 off completely. When Q3 turns off, the normal condition is restored. Q10 with R28, R29, and R30, form a foldback current limiter for the −15 volt regulator.

The +3.6 volt supply is provided by Q5 and Q6 operating as a Comparator Differential Amplifier controlling the Series Pass transistor Q7. The error signal is obtained from the wiper of R20, in a Voltage Divider comprised of R18, R20, and R21 between +3.6 volts and −15 volts (the −15 volts here acts as a reference voltage) and R2 is used as the +3.6 volt adjustment.

The −3.6 volt supply is provided by IC2 operating as a Unity Gain Operational Amplifier.

3.3 SUPPLEMENTAL CIRCUITS

There are no unique or supplemental circuits within the Model 740 to be separately described as "Supplemental Circuits". The preceding circuit descriptions adequately describe the complete circuitry of the Model 740 to the degree required by a competent technician.

SECTION 4
MAINTENANCE

4.1 ACCESS INSTRUCTIONS

Removal of the dust cover affords quick access to the majority of components within the unit. However, it may be necessary to remove the Zero Crossing Board in order to gain access to those components not exposed by removing the dust cover. Instructions for both are given below.

4.1.1 Removing the Dust Cover

To remove the dust cover (case) from the Model 740 Phase Meter, the following procedure should be followed.

1. Unplug the power cord.
2. Unscrew two captive screws on rear panel.
3. Remove rear casting.
4. Set instrument face down on soft surface and, watching clearance between bottom board and cover, lift cover off slowly.
5. Reverse this procedure when replacing dust cover. Tighten the captive screws only finger-tight.

4.1.2 Removing the Zero Crossing Board

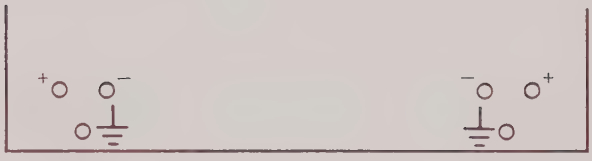
To remove the Zero Crossing Board from the Model 740 Phase Meter, proceed as follows:

1. Set instrument on its side and disconnect the pins of the two sets of three input connectors. These are located near the front of the bottom board.
2. Remove the three bottom screws on both sides of the instrument holding the Zero Crossing Board to the side plates.
3. Slide Zero Crossing Board back until printed circuit board clears the front panel.
4. Swing the Zero Crossing Board out from the front and replace the screws at the rear of the board. This allows the user to get at both sides of the Zero Crossing Board while the instrument is operating.

NOTE

The inputs are now available at the pins on the front of the Zero Crossing Board.

5. To replace the Zero Crossing Board, reverse the above procedure. When reconnecting the input pins, use the following diagram.



Component Side of Zero Crossing Board

4.2 CALIBRATION INSTRUCTIONS

This paragraph provides complete sequential calibration instructions for the Model 740 Phase Meter. The instructions are concise and are written for the experienced electronics technician or field engineer having a working knowledge of this type of instrumentation.

WAVETEK maintains a factory repair department for those customers not possessing the necessary test equipment or personnel to maintain this type of instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached. This will hasten turnaround time.

Test point and control locations necessary for calibration are given within this section unless a foldout illustration is required. In the latter instance, the foldout illustration will be found at the rear of the manual.

4.2.1 Recommended Test Equipment

The following test equipment (or equivalent) is recommended for this calibration procedure.

VCG/VCA Generator	Wavetek Model 136
Voltmeter	1 mV Resolution
Phase Angle Generator	Dytronics Model 410
Oscilloscope	Tektronix Model 454
Flat-bladed screwdriver	1/8-inch

4.2.2 Preliminary Procedures

Before attempting to recalibrate this instrument, the user should read and understand the entire calibration proce-

dure. The four major segments of this procedure should be performed in the sequence given, as should the steps within each segment.

1. Connect the Model 740 Phase Meter in the test set up illustrated in Figure 4-1[A].
2. Set POWER switch to ON, set METER SENSITIVITY selector for ±180° and allow a 30-minute warmup period before attempting to calibrate this instrument.

4.2.3 Full Scale Calibration Procedure

3. With equipment connected as shown in Figure 4-1[A]; hold CALIBRATE switch up (+180.0) and adjust +180.0 ADJ R79 for −1.800 volts plus or minus 0.3 mV on dc output.
4. Hold CALIBRATE switch down (−180.0) and adjust −180.0 ADJ R81 for +1.800 volts plus or minus 0.3 mV on dc output.

4.2.4 Logic Board Calibration Procedure

NOTE

Perform steps 5 through 13 only if steps 3 and 4 do not meet specifications.

5. Remove the dust cover and the display unit from the Model 740 Phase Meter following the procedures outlined in paragraph 4.1.1.

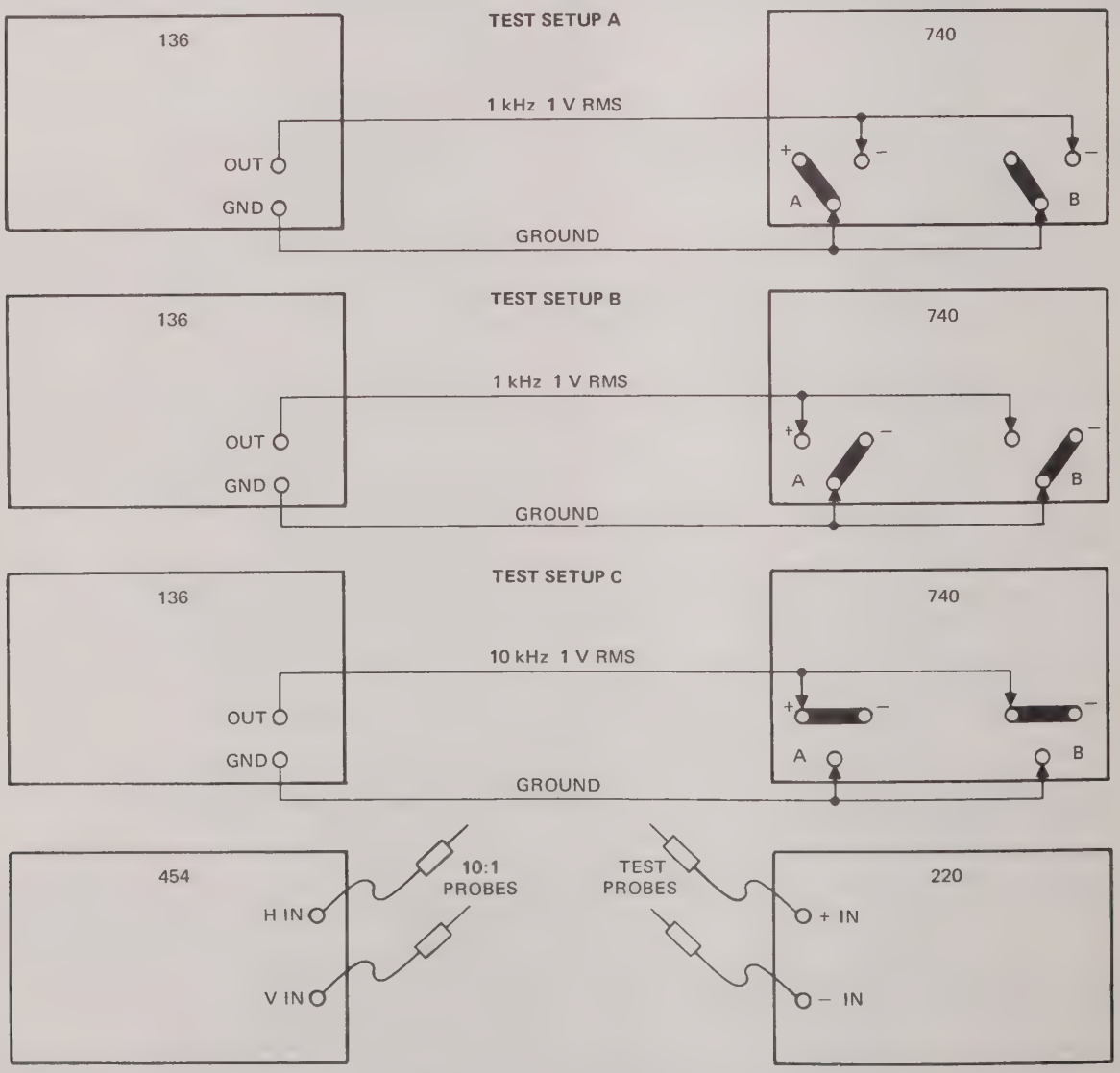


Figure 4-1. Calibration Set-Up

6. Connect the voltmeter to the +3.6 V supply at test points TP1 and TP2 (Figure 4-2).
7. Set POWER switch to ON and allow a 30-minute warmup period before attempting to calibrate this instrument.
8. Set METER SENSITIVITY selector for ±180°, and OFFSET switch to OUT. Ignore the front panel meter reading.
9. Adjust −15 V ADJ R36 while monitoring the +3.6 V supply, and set to +3.600 V ±2 mV.
10. Connect the voltmeter to the OUTPUT −10mV/DEG dual-banana plugs.
11. Hold CALIBRATE switch up (+180.0) and adjust +180.0 ADJ R81 for +1.800 V ±.3 mV on the voltmeter.
12. Hold CALIBRATE switch down (−180.0) and adjust −180.0 ADJ R79 for −1.800 V ±.3 mV on the voltmeter.
13. Repeat steps 11 and 12 and, if readings within ±.3 mV cannot be obtained, performs steps 1 through 4 and repeat steps 8 through 12. If proper indications still cannot be obtained, refer to the trouble shooting instructions given in Section 4 of this manual.

4.2.5 Zero-Crossing Mid-Frequency Procedure

14. Turn power on and short out resistors R1, R5, R92, and R96 with short jumper wire or clip leads.
15. Connect a 1 kHz sine wave, 10 mV rms (28 mV p-p), into each input (Figure 4-1[A]).
16. Check 10:1 oscilloscope probe for dc zero, by putting scope probe on GND banana plug and center trace on horizontal centerline of CRT. Set scope gain to 10 mV/centimeter, and sweep speed to 0.1 ms/centimeter.
17. Connect the scope probe to Channel A test point TP2 (Figure 4-3) of the Zero Crossing Board. The oscilloscope should display a waveform similar to the one shown in Figure 4-4[B].
18. Adjust DC BALANCE ADJ R28 so that V1 is equal to V2 (±10 mV).

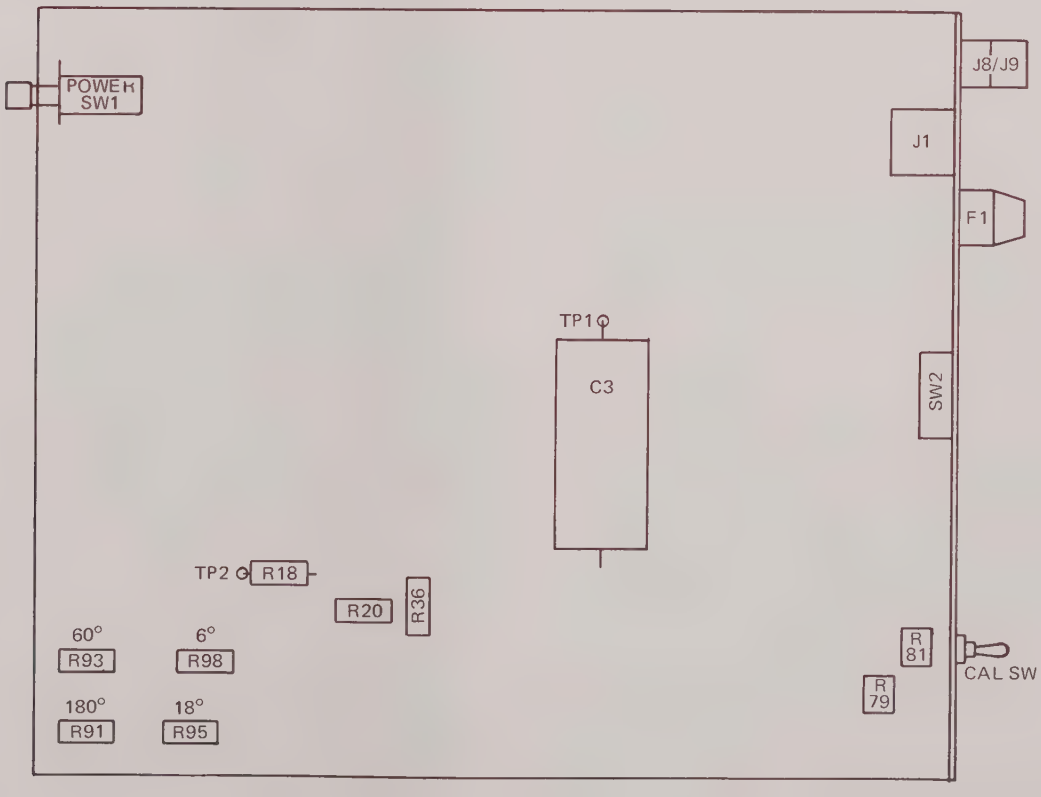


Figure 4-2. Logic Board Adjustment Locations.

19. Adjust CHOPPER BALANCE ADJ R64 so that t_1 is equal to t_2 (±1 μS).
20. Alternately perform steps 18 and 19 until the closest to optimum results are obtained.
21. Adjust TD ADJ R63 until top of tunnel diode trigger is at zero volts dc (±1 mV) as shown in Figure 4-4[B].
22. Connect scope probe to test point TP5, adjust DC BALANCE ADJ R119, CHOPPER BALANCE R155, and TD ADJUST R154 and perform steps 18 through 21 for Channel B. Recheck oscilloscope for dc drift by connecting the scope probe to the phase meter ground and adjusting scope controls to reposition trace on horizontal center line.
23. If steps 14 through 22 have been followed correctly, the dc output should equal one half of plus and minus full scale (CALIBRATE switch up and down readings). This reading is called "out of case zero" in the rest of the manual.

Examples:

Calibrate "Up"	Calibrate "Down"	"Out of Case Zero"
+180.0	−180.0	0.0 (±.1°)
+180.2	−179.8	+0.2 (±.1°)
+180.2	−179.4	+0.4 (±.2°)

N O T I C E

Do not be alarmed if the full scale values are not precise, the instrument is out of the case and will return to proper readings when case is replaced. It is important, however, that the "out of case zero" be displaced equally from the range extremes.

DO NOT READJUST
FULL SCALE VALUES AT THIS POINT

If "out of case zero" is not equally displaced repeat steps 14 through 22 and step 24 below. Go on to the Zero Crossing High Frequency Procedure; three or four tenths of a degree error could be caused by high frequency misalignment.

N O T I C E

24. Increase the input signal amplitude to both channels to 1 V rms (2.8 V p-p). If reading changes more than ±0.1°, adjust PK-PK ADJ R21 and R112 for accurate time symmetry at test points 2 and 5, as shown in Figure 4-4[C].

4.2.6 Zero-Crossing High-Frequency Procedure

25. Short out resistors R1, R5, R92, and R96 with short jumper wire or clip leads and remove all scope probes.
26. Apply a 10 mV rms sine wave, 80 kHz, into both channels, using the test configuration shown in Figure 4-1[A].
27. Adjust C22 until meter readout is equally displaced from range extremes for "out of case zero" (±0.2).
28. Increase input amplitude to 100 mV rms, increase input frequency to 800 kHz, and adjust C10 until the meter readout equals "out of case zero" (±.4°).
29. Since steps 27 and 28 interact, they must be alternately performed until both readings, when going from one condition to the other, are within limits. Recheck steps 17 through 22 and, if necessary, readjust controls for proper indications.
30. Apply a 1 mV rms sine wave to both inputs, using the configuration shown in Figure 4-1[A] and, while watching the meter readout, vary the frequency from 1 kHz to 10 kHz. Record the reading at 1 kHz and the reading at 10 kHz. Determine the difference between the two readings, taking into account the polarities indicated, and record this as the "error span".

Examples:

1 kHz Readings	10 kHz Readings	Error Span
−000.1	+001.0	1.2°
+000.2	+001.1	.9°
−000.2	−000.8	.6

31. Set input frequency back to 1 kHz at 1 mV rms and equally adjust Channel A Tunnel Diode ADJ R63 and Channel B Tunnel Diode ADJ R154 so that the meter indicates one-third of the Error Span with a minus sign. (This would be 0.4° in the first example shown in step 30.)
32. Set input frequency to 10 kHz at 1 mV rms and meter should indicate two-thirds of the Error Span. If the Error Span is not distributed one-third and two-thirds at 1 kHz and 10 kHz respectively, repeat steps 30 and 31.

4.2.6.1 COMMON MODE REJECTION CALIBRATION

33. Apply a 10 kHz, 10 mV rms, sine wave to both inputs as shown in Figure 4-1[C]; with R1, R5, R92, and R96 shorted out.
34. Connect scope probe to test point TP2, and alternately adjust R187 and C11 for minimum signal. Increase input to 1 V rms and adjust for double input frequency at TP2.
35. Connect scope probe to test point TP5, and alternately adjust R190 and C139 for minimum signal with 10 mV

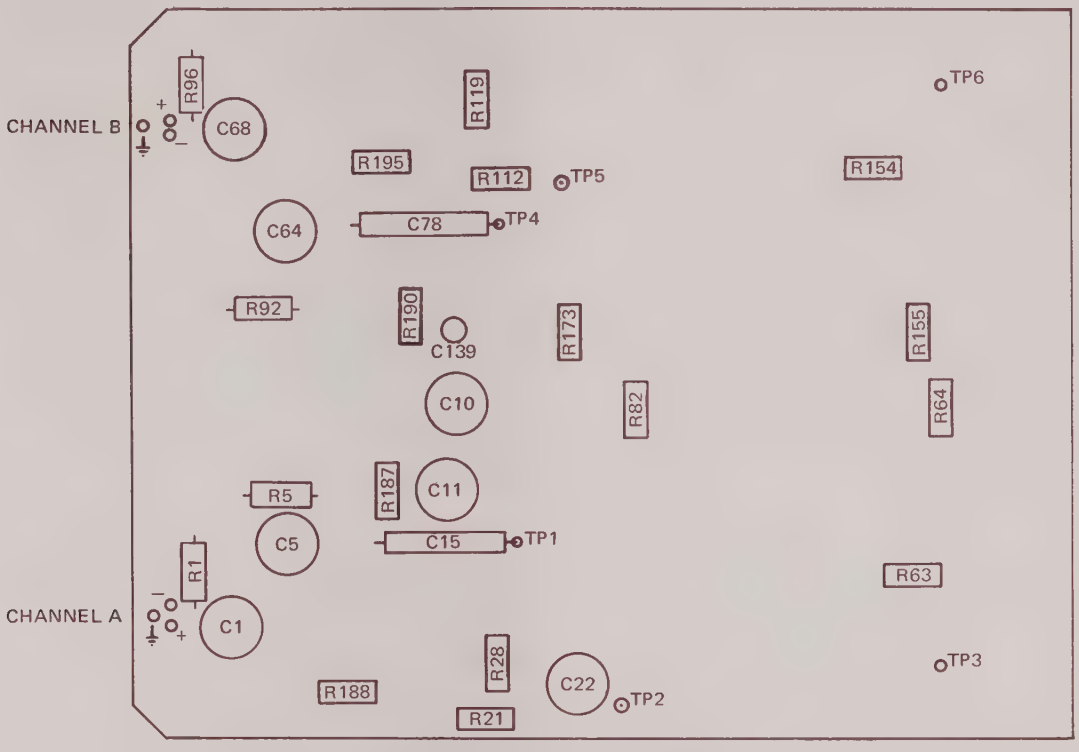


Figure 4-3. Zero Crossing Board Adjustment Locations

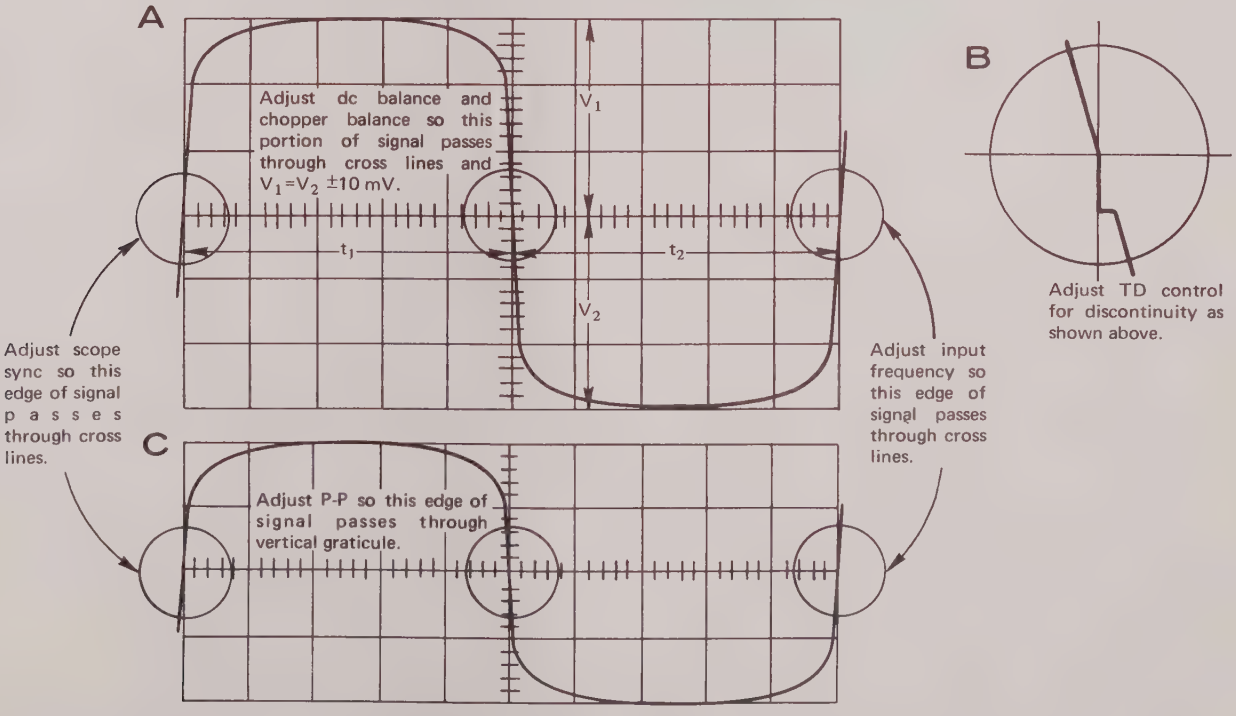

A
Adjust dc balance and chopper balance so this portion of signal passes through cross lines and $V_1 = V_2 \pm 10$ mV.
V_1
V_2
t_1
t_2
Adjust scope sync so this edge of signal passes through cross lines.
Adjust input frequency so this edge of signal passes through cross lines.
B
Adjust TD control for discontinuity as shown above.
C
Adjust P-P so this edge of signal passes through vertical graticule.

Figure 4-4. Oscilloscope Calibration Displays

input. Increase amplitude to 1 V rms and adjust for input frequency doubling at TP5.

NOTE

Minimum signal refers to minimum amplitude of frequency applied to input.

4.2.6.2 ATTENUATOR FREQUENCY ADJUSTMENT

36. Remove jumpers from R1, R5, R92, and R96 and apply a 1 kHz, 7 V rms sine wave to the positive input terminals as shown in Figure 4-1[B]. Connect the probes of a dual channel scope, with lissajous capability, between the plus input terminal and test point TP1 of Channel A.
37. While varying the input frequency from 1 kHz to 10 kHz, adjust C1 for a closed lissajous.

NOTE

Make sure the oscilloscope probes are properly compensated for lissajous operation. Check each probe with the scope calibrate signal, then connect both probes to the same signal and vary the frequency from 10 Hz to 1 MHz and make final adjustment for closed lissajous.

38. Connect the scope probes from TP1 to TP4 of Channel B. Adjust C64 for a closed lissajous. The meter should now read within ±.2° of reading obtained with 100 Hz input (switch to 100 Hz without changing amplitude and check). If it doesn't, repeat steps 36 and 37 until the indication is within this limit.

4.2.6.3 ATTENUATOR COMMON MODE REJECTION ADJUSTMENT

39. With the jumper removed from R1, R5, R92, and R96 apply a 7 V rms 25 Hz sine wave to both inputs as shown in Figure 4-1[C].
40. Connect scope probe to test point TP2, and adjust R188 for minimum signal.
41. Increase input frequency to 25 kHz, and adjust C5 for minimum amplitude at TP2.
42. Connect scope probe to test point TP5, decrease input frequency to 25 Hz, and adjust R195 for minimum signal.
43. Increase input frequency to 25 kHz, and adjust C68 for minimum amplitude at TP5.
44. Repeat steps 39 through 43 if required.
45. Replace the dust cover by following the instructions in paragraph 4.1.1; apply POWER, and allow 20 minutes for the unit to reach a stable operating temperature.
46. Check plus and minus full scale calibration applying the same sine wave, 1 kHz at 1 V rms, to both inputs as shown in Figure 4-1[A].

4.2.6.4 HIGH AND LOW AMPLITUDE ADJUSTMENT

47. With jumper removed from R1, R5, R92, and R96 apply a 1 kHz, 5 V rms, sine wave to INPUT A. Apply a 50 mV sine wave to INPUT B.
48. Reading should be less than ±1.5°. If not, adjust TUNNEL DIODE ADJ R154 until reading is less than 1.0°.
49. Apply a 1 kHz, 5 V rms, sine wave to INPUT B and apply a 50 mV sine wave to INPUT A.
50. If reading is not more than 1.5° adjust TUNNEL DIODE ADJ R63 for less than 1.0°.
51. Apply a 1 kHz, 50 mV rms, sine wave to INPUT A and INPUT B. Reading should be less than 1.5° (typically ±0.5°) repeat steps 47 through 50 until the meter is within this limit.

4.2.6.5 METER CALIBRATION

NOTE

The meter calibration can only be as accurate as the test equipment used in calibration; therefore, a ±0.1° phase angle generator is recommended.

52. With power off, mechanically zero meter.
53. Connect 740 to a phase angle generator with ±0.1° or better accuracy.
54. Turn 740 power on and let stabilize for 20 minutes.
55. Place the OFFSET switch in OUT position.
56. Select ±180° METER SENSITIVITY. Set phase source to 180° at 1 kHz, 1 V rms into both inputs, and adjust 180° meter ADJ R91 for full scale reading. See figure 4-2. Interchange inputs (exchange Channel A's input with Channel B's input), note error on meter, and adjust out ½ of error with R91.
57. Select ±60° METER SENSITIVITY. Set phase source to 60° at 1 kHz, 1 V rms into both inputs and adjust 60° meter ADJ R93 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R93.
58. Select ±18° METER SENSITIVITY. Set phase source to 18° at 1 kHz, 1 V rms into both inputs and adjust 18° meter ADJ R95 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R95.
59. Select ±6° METER SENSITIVITY. Set phase source to 6° at 1 kHz, 1 V rms into both inputs and adjust 6° meter ADJ R98 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R98.

4.3 CORRECTIVE MAINTENANCE

If the Model 740 Phase Meter appears to be operating abnormally, and an investigation of input/output connec-

tions, as well as a calibration check, do not cure the problem; follow the trouble-shooting procedure outlined below.

Trouble	Check
1. Meter jumping around when no input signal is applied.	Normal operation, the high sensitivity of the input picks up external 60 Hz noise.
2. Meter jumping occasionally with low input amplitude and/or frequency.	Noise spikes are riding on input signal or signal-to-noise ratio is too high. Put 0.1 μF capacitors, or matched filters, across inputs.
3. Meter jumping randomly with input signal applied.	a. Check that phase angle is not within 2° of +180° or −180°. If it is, reverse input connection of INPUT A and subtract 180° from reading. This places reading away from ambiguity. b. Reduce ground loops, and use differential inputs isolating grounds.
4. Erroneous phase reading.	a. Check rms voltage of inputs. Overdrive causes phase errors. b. Quick check CALIBRATE limits. c. If "a" and "b" do not help, apply same input to both channels, if reading is within specifications. recalibrate Zero Crossing board.
5. Display not lighted when POWER is set to ON.	Check fuse. Check ±15 V, and ±3.6 V power supplies.
6. Display locked on maximum or minimum full scale regardless of inputs.	a. If locked on maximum, check Channel A Zero Crossing for no output. b. If locked on minimum, check Channel B Zero Crossing for no output. c. If not "a" or "b" check IC4 on the Logic and Power Supply board.
7. Input loading circuit being measured due to low input impedance.	Input FET has been damaged. Replace with MPF104 or 2N5458 or equivalent.

If the instrument is not operating properly, and the above steps do not solve the problem, recalibrate the instrument as described in paragraph 4.2. If recalibration does not solve the problem, follow the procedure outlined below.

1. First check all power supplies for proper operation. If any are malfunctioning, refer to the Circuit Description as well as the schematic when trouble shooting the supply.
2. With 1 kHz 1 V rms sine waves applied to both inputs, look at Zero Crossing test points TP3 and TP6. If 3 V pulses at 1 kHz are not observed, read Circuit Description and refer to the schematic for trouble shooting.
3. If the proper pulses are seen in step 2 above, look at the junction of R65, R66, and R68. This point should show a waveform like that pictured below.

SECTION 5
NOTES AND ADDENDUMS

5.1 ADDENDUMS

WAVETEK'S product improvement program incorporates the latest electronic developments into these instruments as rapidly as development and testing permit. Due to the time required to document and print these instruction manuals, it is not always possible to include the change information in the final printing. When this occurs, change pages or addendum sheets are prepared for insertion immediately behind the title page. If no such pages exist, the manual is correct as printed.

5.2 NOTES

The space below may be used to record pertinent data relating to a specific unit, or general information helpful to user. When minor "special" features are requested in the purchase order, WAVETEK will summarize these features below.

SECTION 6
DIAGRAMS

6.1 SCHEMATIC DIAGRAMS

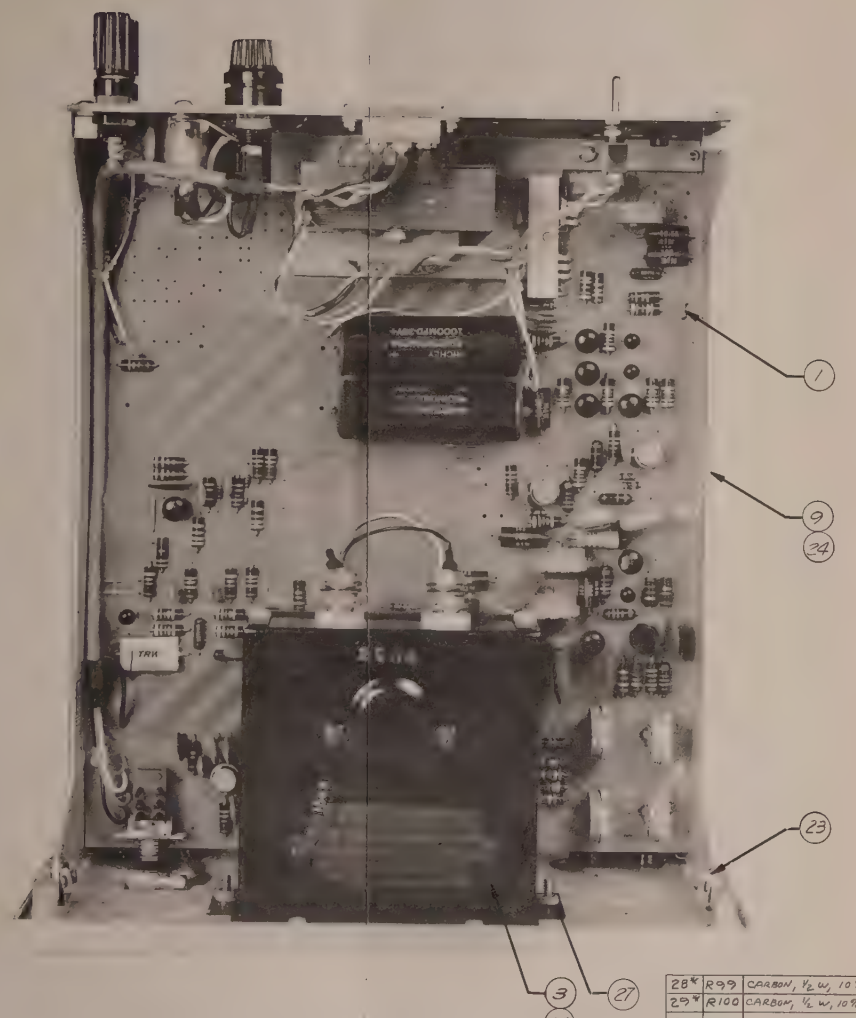
The schematic diagram(s) within this manual are arranged in conjunction with the assembly drawings for maximum ease-of-viewing. Whenever possible, a schematic is positioned opposite the related assembly drawing for maximum information presentation without resorting to page flipping. Additional voltage and/or waveform information, beyond that given in the circuit description, is shown directly on the schematic diagrams, at test points and key locations throughout the instrument.

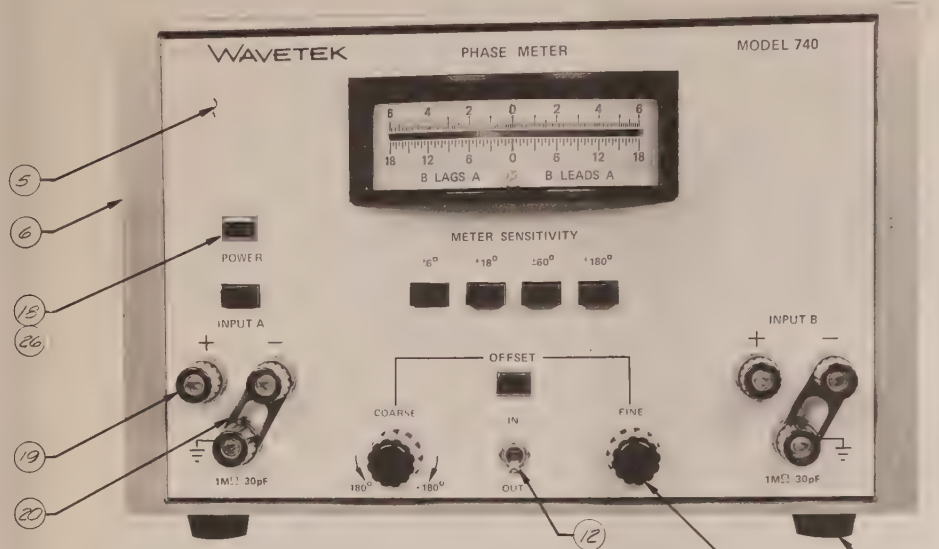
6.2 ASSEMBLY DRAWINGS AND PARTS LISTS

Reproductions of WAVETEK'S actual production drawings are included within this manual so the user will have complete parts location information as well as the most recent parts lists. The following list of manufacturers should be used in conjunction with the parts lists.

LIST OF MANUFACTURERS

A/B	Allen Bradley
ALCO	Alco Electronic Products Inc.
AMELCO	Teledyne Amelco Semiconductor Co.
American Radionics	American Radionics, Inc.
AMP	Amp Inc.
ARCO	Arco Electronics
BELDEN	Belden Corp.
Boots Aircraft	Boots-Townsend Aircraft
BUDWIG	Budwig Mfg. Co.
Burroughs	Burroughs Electronic Components Division
C&K	C and K Components
CDE	Cornel Dublier Electronic Division
Cinch Jones	Cinch Mfg. Company
CORNING	Corning Glass Works
CRL	Centralab, Division of Globe-Union
CTS	CTS Electronics Inc.
Deutsch	Deutsch Fastener Corp.
Electro Cube	Electro Cube, Inc.
ELCO	Elco Corp.
ELMA	Elma Engineering
ELPAC	Elpac Incorporated
ERIE	Erie Technological Products Inc.
Fairchild	Fairchild Semiconductor Corp.
GE	General Electric
GR	General Radio Co.
HP	Hewlett-Packard
IBM	IBM Industrial Products
IMB	IMB Electronics Products
IRC	IRC Inc.
JOHNSON	E. F. Johnson Co.
KINGS	Kings Electronics Inc.
Littelfuse	Littelfuse Inc.
Micro Ohm	Micro-Ohm Corp.
Milton Ross	Milton Ross Co.
Motorola	Motorola Semiconductor Products
MURA	Mura Corp.
PHIPPS	Phipps Precision Products
QUALITY	Quality Hardware Mfg.
RCA	RCA Semiconductor Division
RICHEY	Richey Electronics
ROSAN	Rosan Inc.
Rubber Teck	Rubber Teck Inc.
SEMTECH	Semtech Corp.
SHURLOK	Shur-Lok Corp.
H H SMITH	Herman H. Smith, Inc.
SPRAGUE	Sprague Electric Co.
Stackpole	Stackpole Carbon Co.
Stettner	Stettner & Co.
Superior	Superior Electric Co.
Switchcraft	Switchcraft, Inc.
TI	Texas Instruments, Inc.
TRW	TRW Capacitor Division
USECO	USECO Inc.
Wakefield	Wakefield Engineering Inc.





NOTE: ASTERISK (*) INDICATES ITEMS NOT SHOWN

PARTS LIST

ITEM NO	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1	A1	LOGIC + POWER SUPPLY BD	WAVETEK	C740-010	1
* 2	A2	ZERO CROSSING BD		D740-011	1
3	A11	METER		B740-503	1
* 4		SHIELD		C740-309	1
5		FRONT PANEL	WAVETEK	B740-302	1
6		CASTING		B740-300	1
* 7		REAR PANEL		B740-303	1
* 8		CASTING		B740-301	1
9		SIDE PLATES		C130-304	2
* 10		COVER		C130-353	1
* 11		POWER CORD	BELDEN	17258-S	1
12	SW3	SWITCH DPDT	C+K	7201	1
13	R201, R202	POTENTIOMETER	CTS	UA1590G	2
14		BAIL KIT	WAVETEK	B130-507	1
15		FASTENER	TINNERMAN	C7494-632-4	6
* 16		FASTENER	CARR	PC47291	2
17		KNOB (BLACK)	ELMA	020-322	2
18		LENS (RED)	ALCO	BNG-51	2
19	J2345&7	CONNECTOR, BINDING POST	SUPERIOR	DF21BC	6
20		SHORTING BAR	G R	938-L	2
21 *		CAPTIVE SCREW	DEUTSCH	DKN7100-10-82	2
22		SOLDER LUG	SMITH	1468	2
23		CLIP NUT (#6-32)	SMR LOK	SL210-06-2	4
24		CHASSIS BLOCK	USECO	1591-811	5
25		KNOB CAP (BLACK)	ELMA	040-302	2
26	L1&2	LAMP	MURA	L28-40	2
27		PRESS BOLT	ROSAN	PB-6-32-SH-6	2
28 *	R99	CARBON, ¼ W, 10%, 560K	STACKPOLE	RC20GFGR564K	1
29 *	R100	CARBON, ¼ W, 10%, 18K	STACKPOLE	RC20GFGR183K	1
30					

rev	ecn	by	date	app
F	ECN 1336	[illegible]	9-5-5	[illegible]
E	ECN 458	SH	9-8-72	
D	ECN 436	SH	8/9/72	
C	ECN 414	S	8/4/72	S
B	ECN 389 (PARTIAL ITEMS 28 & 29	[illegible]	7-1-72	
A	ECN 294	DW	1/27/72	[illegible]

tolerance unless otherwise specified: XXX ± .010, XX ± .030
scale: N/A
material: N/A
finish: N/A

WAVETEK san diego calif.
by GRAY date 11.7.69 app [illegible]
title: CHASSIS ASSY
model no. 740
dwg no. D740-000
rev F

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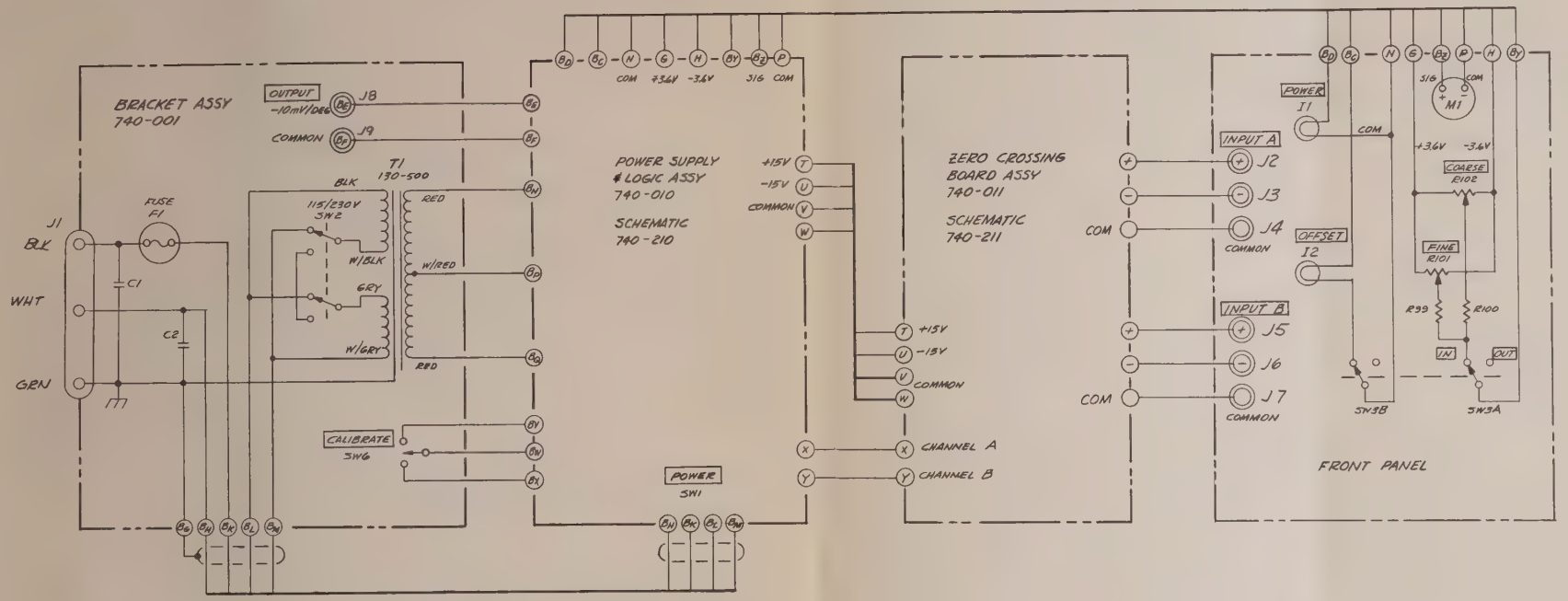

NOTES: UNLESS OTHERWISE SPECIFIED
1. LETTERS ARE INTERCONNECTION POINTS.

rev	ecn	by	date	app.
A	E94	NG	12/1/70	AP

tolerance unless otherwise specified
.XXX ± .010
.XX ± .030

WAVETEK san diego, calif

scale NA | by MAST | date 9DEC69 | app.

material: NA

title: SCHEMATIC, CHASSIS

model no. 740 | dwg no 740-200 | rev A

finish: NA

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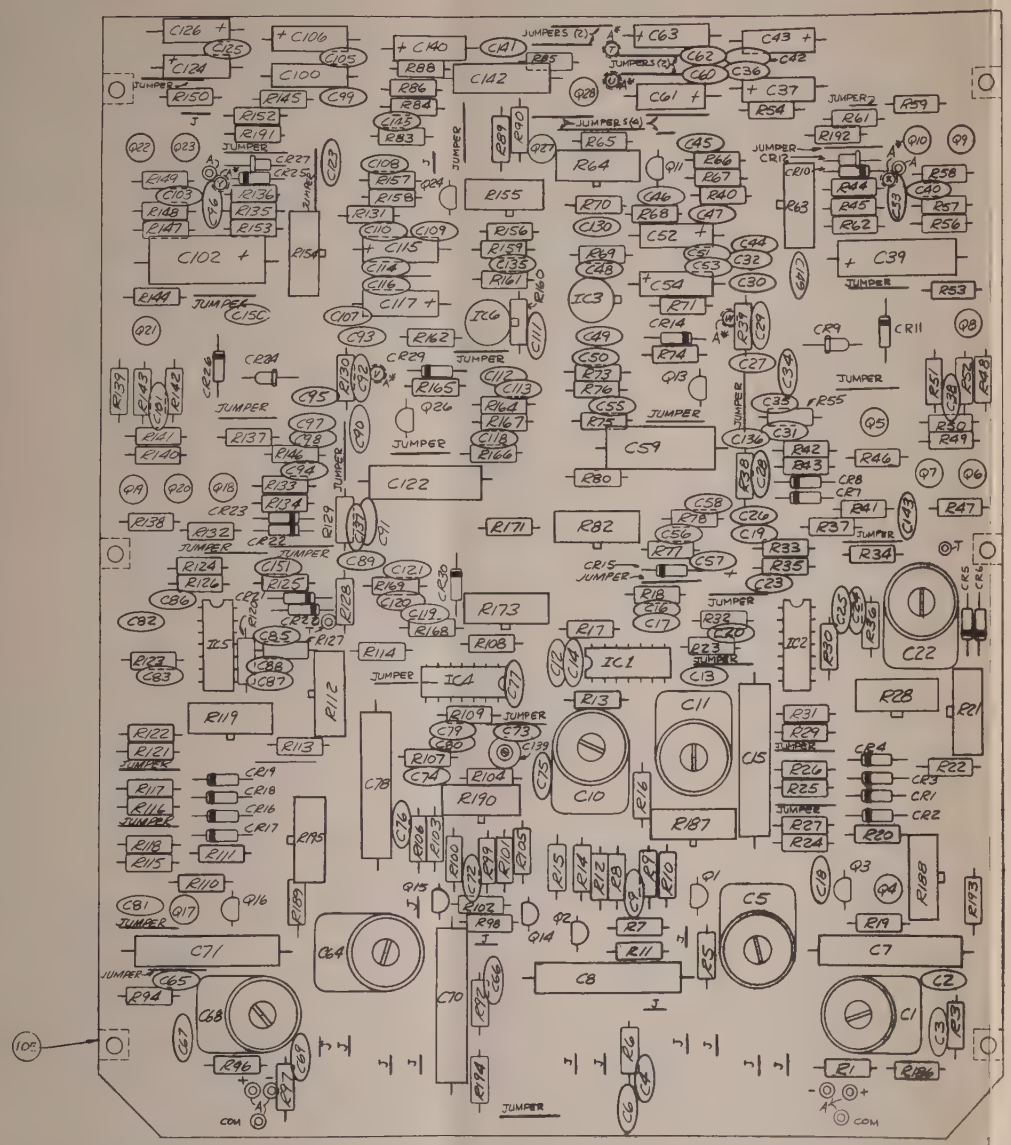

NOTES: UNLESS OTHERWISE SPECIFIED
1. "AK" INDICATES AMP PIN MOUNTED ON CIRCUIT SIDE; "A", AMP PIN MOUNTED COMPONENT SIDE.
2. FOR INTERCONNECTIONS REFER SCHEMATIC 740-200
3. "J" INDICATES JUMPER.
4. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1	C6, C6, C68 C69, C73 C89,	CERAMIC DISC 100DV 5pF	CRL	DD-050	6
2	C130, C135	1.5 pF	SPRAGUE	10TCC-Y15	2
3	C29 C53, C71 C86-C88	10pF	CRL	DD-100	7
4	C18, C81	15pF		DD-150	2
5	C14, C17, C49 C145, C146 C148, C150, C151	22pF		DD-220	10
6	C48, C50, C79, C101, C108	100pF		DD-101	6
7	C48, C111	220pF		DD-221	2
8	C33, C34, C36, C37	330pF		DD-331	4
9	C40, C85 C103, C119	470pF		DD-471	4
10	C55, C118	1500pF		DD-152	2
11	C61, C93	.05μF		CK-503	4
12	C9, C35, C36, C45, C51, C53, C60, C62, C78, C94, C99, C105, C114, C116, C142, C145	50V .01μF		CK-103	19
13	C26 C40, C70, C80, C82, C84, C122, C123, C94, C106, C113, C121,	20V .1μF		UK50-104	18
14	C37, C39, C52, C54, C64, C103, C104, C115, C117, C144, C145, C40	ELECTROLYTIC 15V 5μF	SPRAGUE	500D706B015BAT	13
15	C57, C120	TANTALUM .33μF		196D334X0015FB	2
16	C39, C106	ELECTROLYTIC 16V 100μF		500D107M016DK7	2
17	C89, C122	MYLAR 100V, 10% .1μF	CDE	WMF-1P1E	2
18	C7, C8, C15, C101, C1, C78	200V 1% 1μF	ELECTRO CUBE	2108IC-10SF	6
19	C1, C8, C10, C11, C48	VARIABLE CAPACITOR 4.5-25pF	ERIE	508-001-37A	7
20	C136, C137	SELECTED VALUE			2
21	C139	VARIABLE CAPACITOR 3.5-13pF	STETTNER	75-TRIKO-02	1
22	C44, C66, C67	S.M. (-48) 470PF	ARCO	DM15-471J	4
23	C50, C54, C55, C56, C57	CERAMIC DISC 50V .1μF	CRL	CK104	6
24	C46 C104	MYLAR 50V .1μF	GE	65F13AA104	2
25	C102	MYLAR 100V .047μF	CDE	WMF 1547	1
26	C61, C64, C67, C68, C69, C70, C78, C79, C221, C124, C125, C129, C229, C230	DIODE	FAIRCHILD	FD6666	18
27	C611, CR06			1N34A	2
28	CR12, CR27		G.E.	1N3716	2
29	CR9, CR24			1N3717	2
30	C25+6 CR20+21	(-42)	H.P.	HP5082-2811	4
31					
32					
33					
34					
35	IC3, IC6	INTEGRATED CIRCUIT -75	FAIRCHILD	μA709	2
36	IC1, 2, 4, 5	(-40)	RCA	CA3030	4
37					
38					
39					
40					
41					
42	Q5, Q9, Q10 Q23	TRANSISTORS	FAIRCHILD	2N3640	4
43	Q4, Q6-Q9 Q11, Q18 Q20, Q22			2N3646	11
44	Q28		MOTOROLA	2N4851	1
45	Q11, Q13, Q24, Q26			MPF-104	4
46	Q1, Q2 Q14, Q15	(-37)		MPF-104	4
47	Q3, Q16	(-38)		MPF-104	2
48					
49					
50					
51	R63, R154	POTENTIOMETER 1K	CRL	BA1603-803	2
52	R21, R188 R116, R155 R190, R207	10K		-805	6
53	R29, R59 R179, R173	100K		-819	4
54	R64 R155	10K	A/B	FR103M	2
55					

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
56	R46, R137	METAL FILM 1/4W 1% 46.4Ω			2
57	R82, R68 R153, R156	1% 3.32K			4
58	R42, R43 R133, R134	4.99K			4
59	R14, R15, R106, R106	10K(-4)			4
60	R286	19.1K			1
61	R13, R16 R104, R107	12.1K(-33)			4
62	R40, R131	27.4K			2
63	R7, R11, R98, R102	1MΩ			4
64	R1, R5, R192, R296	1MΩ(-34)			4
65	R1, R6, R194	47.5K			2
66	R193, R189	46.4K			2
67					
68					
69	R85	CARBON 1/2W 10% 220Ω	STACKPOLE	RC20GF221J	
70	R49, R54, R71 R78, R88, R89 R97, R110, R119 R149	CARBON 1/2W 5% 47Ω	STACKPOLE	RC20GF470J	9
71	289	68Ω		680	1
72	R3, R6, R19, R38, R88, R94 R97, R110, R119 R149	10% 100Ω		101K	10
73	R91, R182 R139, R141	150Ω		151K	4
74	R177, R99, R104, R134 R146, R184	470Ω		471K	4
75	R45, R47, R49, R50, R74, R89, R136, R152, R168, R169, R169	1K		102K	11
76	R17, R18, R35, R36, R40, R49, R108, R119, R126, R127, R130, R160	1.5K		152K	
77	R53, R90, R134	2.2K		222K	3
78	R8, R99	2.7K		272K	2
79	R191, R192	3.3K		332K	2
80	R94, R125	3.9K		392K	2
81	R22, R30, R46, R48, R52, R113, R135, R140, R143, R120,	4.7K		472K	11
82	R35, R116	5.6K		562K	2
83	R10, R12, R101, R103	6.8K		682K	4
84	R9, R100	5% 7.5K		752	2
85	R84	10% 9.1K		912K	1
86	R20, R26, R27, R31, R32, R111, R117, R140, R147, R148, R171	10K		103K	14
87	R24, R115	22K		223K	2
88	R96, R137	27K		273K	2
89	R31, R193, R75, R122, R184, R146	47K		473K	6
90	R50, R141	62K		623K	2
91	R76, R167	150K		154K	2
92	R74, R165	270K		224K	2
93	R123, R174	470K		474K	2
94	R37-R39 R128-R130	1MΩ		105K	6
95	R70, R161	2.2MΩ		225K	2
96					
97					
98		CIRCUIT BOARD	WAVETEK	740-111C	1
99					
100	◎ T	TERMINALS	USECO	2010B-1	2
101					
102	○ A	AMP PINS	AMP	61182-2	16
103					
104					
105		CHASSIS FASTENER	USECO	1591.8-1	6

REV	BY	DATE	APP.
F	ECN 1336		
E	ECN 83		
D	ECN 580		
C	ECN 457		
B	ECN 413		
A	ECN 294	Bla	1/21/69

tolerance unless otherwise specified .XXX ± .010 .XX ± .030
scale N/A
material N/A
finish N/A

WAVETEK san diego, calif.
by GRAY date 11/26/69 app.
title ASSY ZERO CROSSING BD
model no. 740
dwg no D740-011
rev

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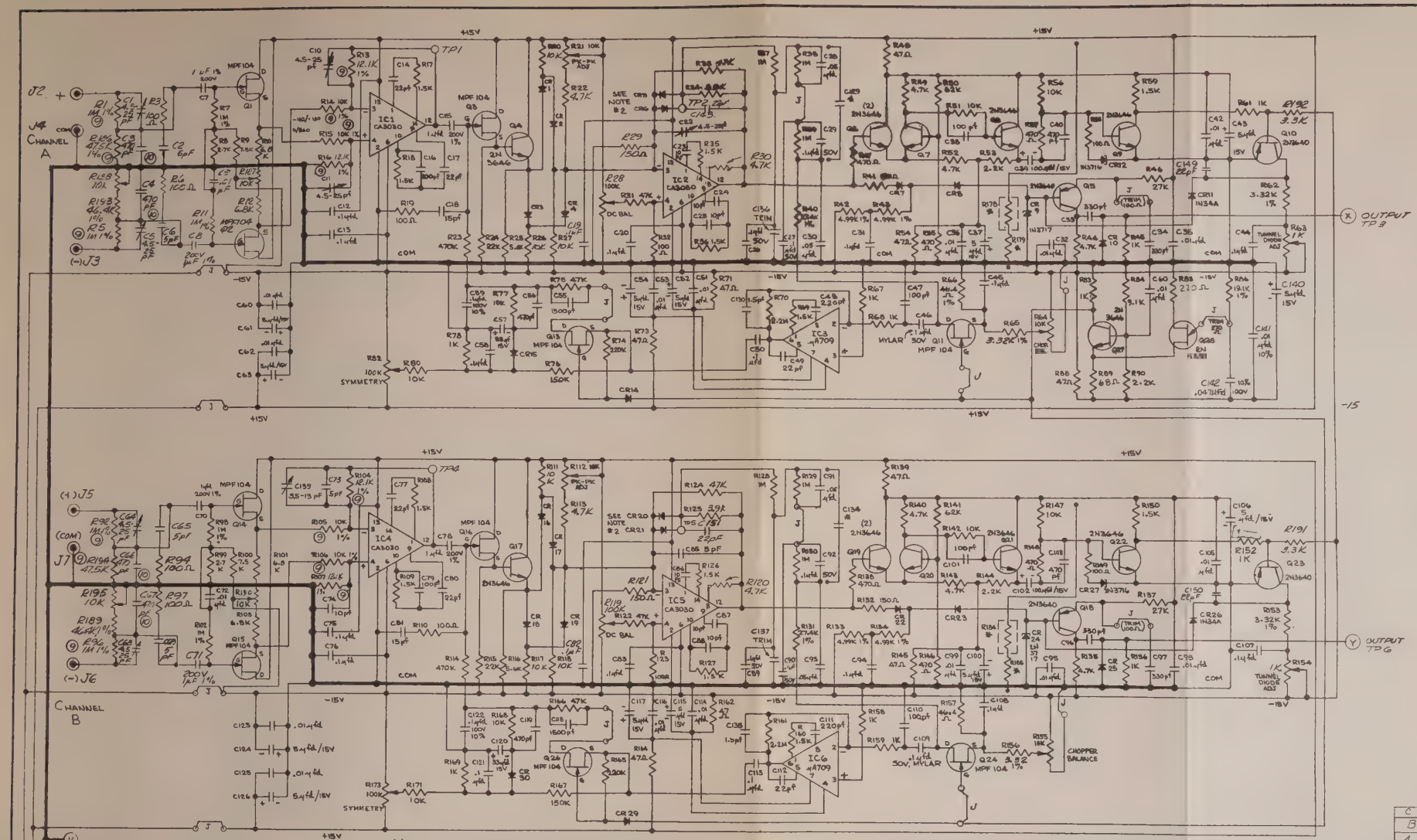

LAST COMP DES. USED

CR30 C151
R198 Q28
TP6 IC6

NOTES:—UNLESS OTHERWISE SPECIFIED—

1. ALL RESISTORS ½ WATT, 10% CARBON
2. HP 2811 DIODES MATCHED
3. ALL DIODES FD6666
4. * INDICATES PROVISIONAL COMPONENTS (R174 THRU R185, R72 & R163 & C127, C128, C129, C132, C133 & C134)
5. R175, 176, 177, 181, 182 & 183 ARE 3.9Ω
6. C127, 128, 132, & 133 ARE 100μfd
7. J INDICATES JUMPER
8. R72 & R165 ARE 1.5K
9. RN60D MATCHED SET
10. MATCHED SILVER MICA SET
11. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.

rev	ecn	by	date	app.
C	ECN 1330	RO	4-5-72	
B	457	DH	9-12-72	
A	294	NG	1/3/70	M

tolerance unless otherwise specified: XXX ± .010, .XX ± .030

WAVETEK San Diego, Calif.

scale N/A | by L. ADAMSON | date 7/A/69 | app.

material: N/A

finish: N/A

title: SCHEMATIC, ZERO CROSSING BOARD

model no. 740 | dwg no. 0740-211 | rev C

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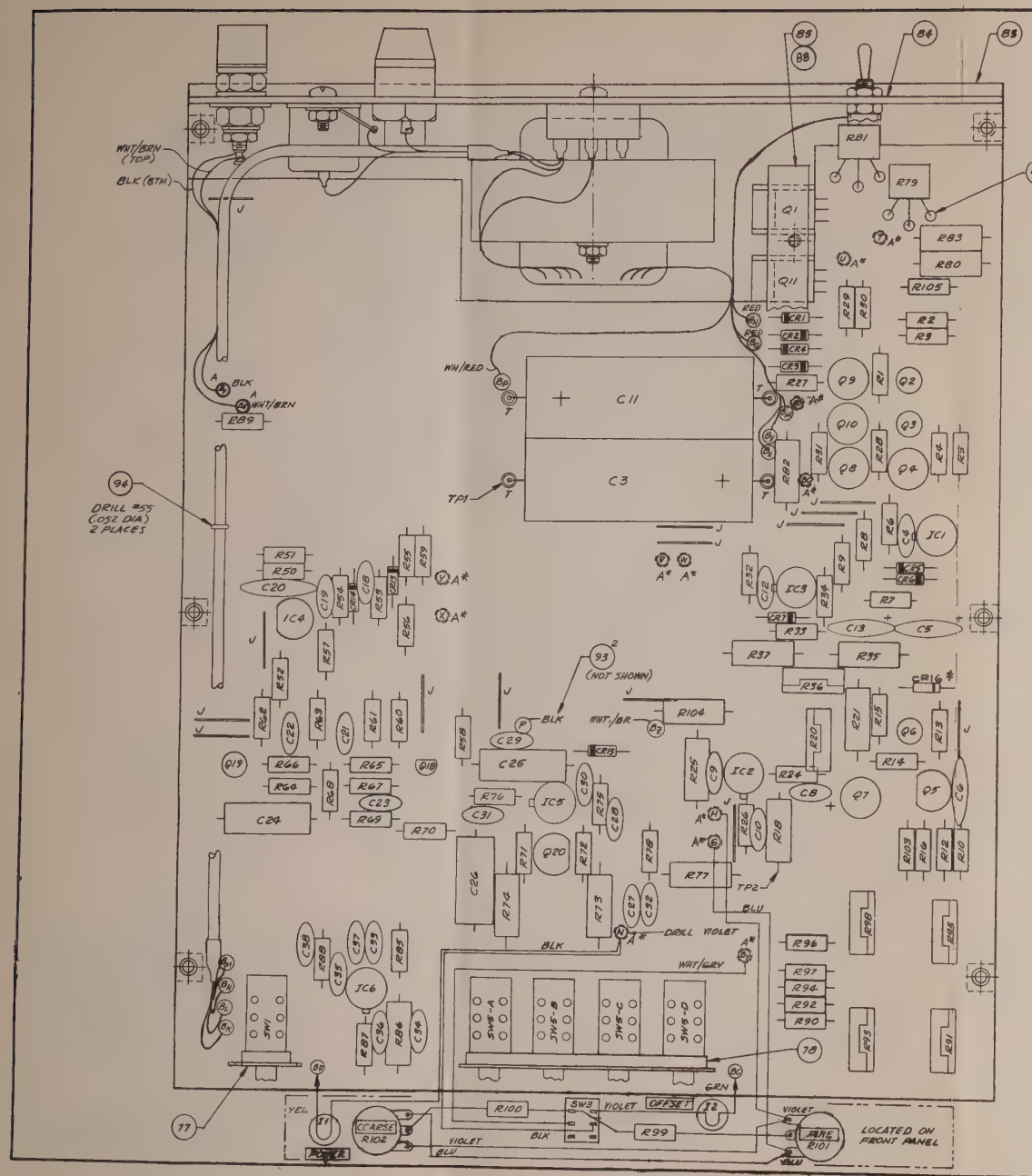

PARTS LIST

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1	C18, C19, C21, C22,	CERAMIC DISC 1KV 22 PF	CIRL	DD220	4
2	C9, C30, C33	220 PF	CIRL	DD221	3
3	C4, C10, C12, C28, C31, C35, C39, C36, C38	50V .005 µF	CIRL	CK502	9
4	C27, C29, C33, C37	.01 µF	CIRL	CK103	4
5	C6, C20, C23	20V .1 µF	CIRL	UK-20-104	3
6	C24, C25, C26	MYLAR 200V .33 µF	TRW	X663F	3
7	C5, C13	TANTALUM 35V 27 µF	SPRAGUE	196D276X0035GB	2
8	C8	15V 33 µF		196D336X0015FB	1
9	C3, C11	ELECTROLYTIC 35V 1000 µF	RICHEY	36-350-1000-35T	2
10					
11					
12	CR16	DIODE, ZENER (-39)	DIXON	IN4581	1
13	CR5, CR6, CR7, CR15	DIODE FDG666	FAIRCHILD	FDG666	4
14	CR13, CR14	HP2811	HP	HP5082-2811	2
15	CR1, CR2, CR3, CR4	3CE-1	SEMTECH	3CE-1	4
16					
17	IC1, IC2, IC3, IC5, IC6	INTEGRATED CIRCUITS	FAIRCHILD	MA709	5
18	IC4			CYL914	1
19					
20					
21	R20, R95, R98	POTENTIOMETER 100 Ω	CIRL	BA1603-B01	3
22	R91, R93	500 Ω		B02	2
23	R36	1K		B03	1
24	R79, R81	(TYPES) 500Ω (-41)	AB	3V5011	2
25					
26	R2, R30, R58	CARBON 1/2W 10% 6.8 Ω	STACKPOLE	RC20GF6R8K	3
27	R52, R97	33 Ω		330K	2
28					
29	R19, R89, R96	100 Ω		101K	3
30	R105	180 Ω		181K	1
31	R94	270 Ω		271K	1
32	R50, R51	330 Ω		331K	2
33	R3, R29	470 Ω		471K	2
34	R61, R62 R89, R92	1K		102K	4
35	R6, R26, R32, R55, R59, R76, R87	1.5K		152K	7
36	R12, R53, R54	1.8K		182K	3
37	R90	3.3K		332K	1
38	R1, R4, R5, R9, R27, R28, R31, R33, R44, R65, R66, R67	4.7K		472K	12
39	R13	5.6K		562K	1
40	R60, R63	15K		153K	2
41	R56, R57	47K		473K	2
42					
43					
44					

ITEM	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
45	R18	WIREWOUND PRECISION 1% 2.37K (-35)	MICRO OHM	TYPE 143	1
46	R35	7.70K (-35)			1
47	R77	9.53K (-35)			1
48	R21, R25, R37 R80, R86, R104	10K (-35)			6
49	R82, R83	19.6K (-35)			2
50					
51	R105	METAL FILM VAW 1/2 464 Ω	CORNING	RN60D	
52	R71, R72	1K			2
53	R16	2.37K			1
54	R34, R85	3.32K			2
55	R24	4.75K			1
56	R10, R14	5.76K			2
57	R7, R8	10K			2
58	R15	19.1K			
59	R68, R69, R70	237K			3
60	R75	698K			1
61	R73, R74	1/2W 1% 2M		RN65D	2
62					
63					
64	Q1	TRANSISTOR TIP29	TI	TIP 29	1
65	Q11	TIP30		TIP 30	1
66	Q2, Q3, Q6	2N3565	FCHILD	2N3565	3
67	Q4, Q8, Q9 Q10	2N3638		2N3638	4
68	Q18	2N3640		2N3640	1
69	Q7	2N3642		2N3642	1
70	Q19 (6)	2N3646		2N3646	1
71	Q5, Q20	TD101	SPRAGUE	TD101	2
72					
73					
74					
75					
76					
77	SW1	SWITCH ASSY, PUSH-PUSH	WAVETEK	E730-JC01	1
78	SW5A, SW5B SW5C, SW5D	SWITCH ASSY, PUSH-LATCH		B730-401	1
79					
80					
81					
82					
83		CIRCUIT BOARD	WAVETEK	740-110	1
84		BRACKET ASSEMBLY		D740-001	1
85		HEATSINK		A130-311	1
86					
87					
88		TRANSISTOR INSULATOR	WAVETEK	A740-307	1
89					
90		TERMINAL	UNECO	20108-1	4
91		TERMINAL		20058-1	6
92		TRANSIPADS	MILTON ROSS	10123N	6
93		SOLDER LUG 1/4	HH SMITH	1468	2
94		MOUSE TAIL	RUBBER TEC	2829-75-2	1
95		AMP PIN	AMP	61182-2	14

NOTES: UNLESS OTHERWISE SPECIFIED
1. T INDICATES TERMINAL.
2. "A" INDICATES AMP PIN MOUNTED FROM NEARSIDE; "A*" INDICATES AMP PIN MOUNTED ON CIRCUIT SIDE.
3.
4. J INDICATES JUMPER.
5. FOR INTERCONNECTIONS REFER TO SCHEMATIC 740-200.
6. NO SUBSTITUTION SHALL BE ALLOWED FOR PART INDICATED.
7. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.

REV	ECN	BY	DATE
G	ECN 1336	BS	5-3-71
F	ECN 897	BS	4-9-70
E	ECN 724	WA	9/69
REV	ECN	BY	DATE
D	ECN 488	WA	3/11/69
C	ECN 413	S	10/31/68
B	ECN 390	WA	9/9/68
A	ECN 294	BS	1/20/68

rev	ecn	by	date	app

tolerance unless otherwise specified .XXX ± .010 .XX ± .030

WAVETEK san diego ca

scale 2X

by W. MAST date 10 NOV 69 app

material NA

finish NA

title ASSEMBLY, POWER SUPPLY & LOGIC

model no. 740

dwg no D740-010

rev G

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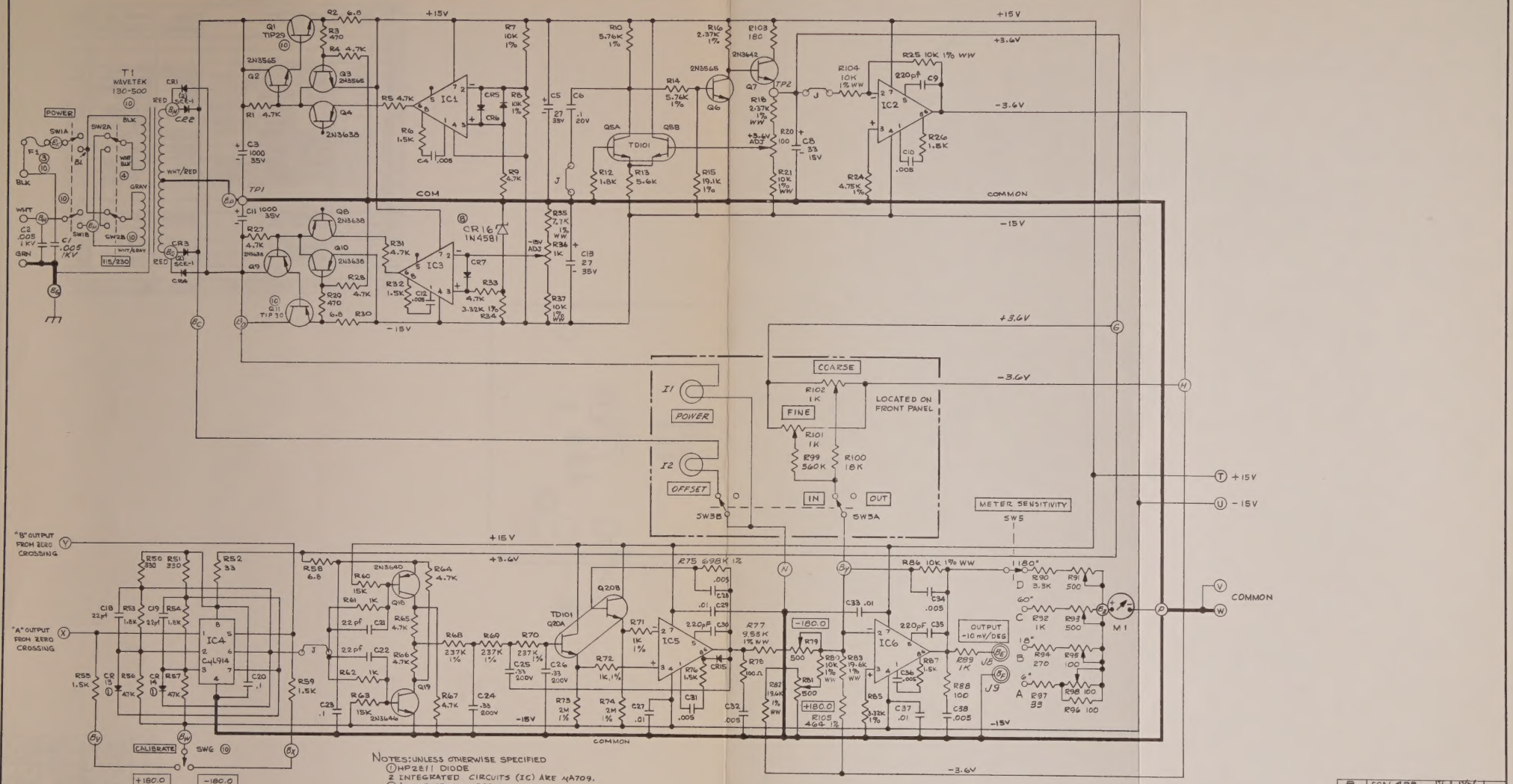
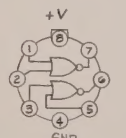
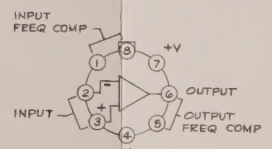


REF DES	LAST USED	NOT USED
DIODE	CR15	CR8 - CR12
CAPACITOR	C38	C7, C14 - C17
INTEGRATED CIRCUIT	IC6	—
TRANSISTOR	Q20	Q13 - Q17
RESISTOR	R105	R11, R17, R19, R22 R23, R38-R43, R64
SWITCH	SW6	SW4
PILOT LIGHT	I2	—
TEST POINT	TP2	—

NOTES: UNLESS OTHERWISE SPECIFIED
1. HP2811 DIODE
2. INTEGRATED CIRCUITS (IC) ARE μA709.
3. 1/2 AMP SB FOR 230V.
   1/4 AMP SB FOR 115V.
4. 115-230 SWITCH SHOWN IN 115 POSITION.
5. J INDICATES JUMPER.
6. ALL CAPACITOR VALUES ARE IN MICROFARADS.
7. ALL DIODES FD6666.
8. SELECTED
9. ALL RESISTORS 1/2 WATT, 10% CARBON; VALUE IN OHMS.
10. COMPONENTS ARE MOUNTED ON REAR BRACKET ASSY.
11. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.





rev	ecn	by	date	app.
B	ECN 498	[illegible]	9/5/74	
A	294	NG	1/29/74	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030

scale N/A

material N/A

finish N/A

WAVETEK san diego, calif.

by L. ADAMSON date 21 NOV 69

title: SCHEMATIC, POWER SUPPLY & LOGIC

model no. 740 | dwg no. 0740-210 | rev B

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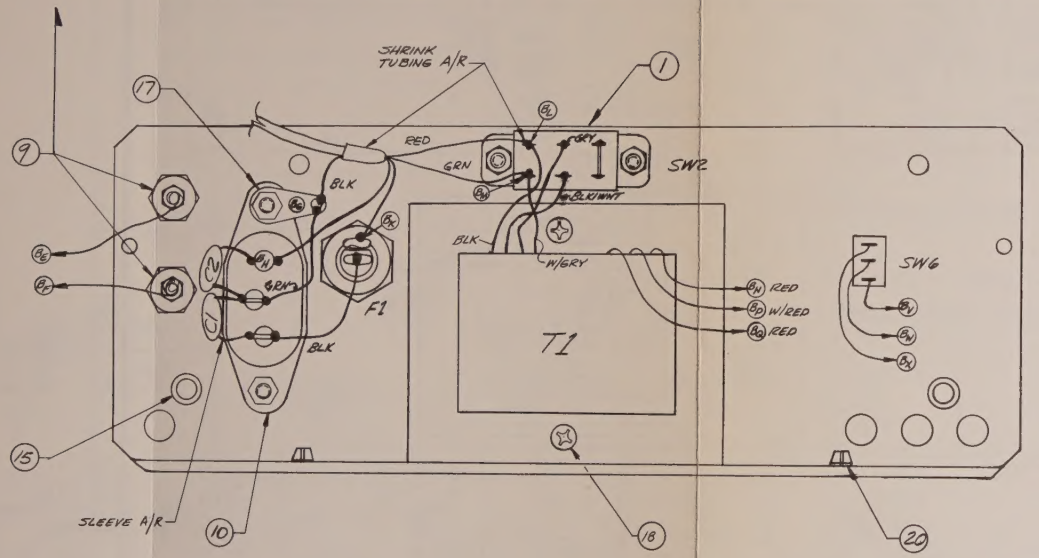
PARTS LIST

ITEM NO	REF DES	DESCRIPTION	MFGR	MFGR NO	QTY
1		BRACKET	WAVETEK	C740-304	1
2					
3					
4	T1	TRANSFORMER	WAVETEK	C130-500	1
5	SW2	SWITCH (115/230)	SWITCH CRAFT	46256 LF SOLDER GUARD	1
6	F1	FUSE HOLDER	LITTEL FUSE	342012	1
7		1/4AMP SB (115V)		313-250	1
8		1/8AMP SB (230V)		313-125	1
9	J8, J9	BINDING POST	E.F. JOHNSON	111-103	2
10	J1	POWER RECP	SWITCH CRAFT	LAC3G	1
11	SW6	SWITCH SPDT(MOMENTARY)	C+K	TG3-7105	1
12	C1, C2	CAPACITOR CER. DISC. 1000V, .005μF	CRL	DD-502	2
13					
14					
15		PRESS NUT	ROSAN	MRPN-10-32	2
16					
17		SOLDER LUG	H.H. SMITH	#13-6	1
18		STANDOFF	H.H. SMITH	2342	2
19					
20		BOOTS NUT 6-32	BOOTS AIRCRAFT	TBID-100-(32)	2



NOTES : UNLESS OTHERWISE SPECIFIED
1. FOR INTERCONNECTIONS REFER SCHEMATIC 740-200
2. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.
3. WIRE COLORS INDICATED ARE FOR REFERENCE ONLY.

rev	ecn	by	date	app.
D	ECN 722	UW	9/23/71	E
C	ECN 413	S	9/27/71	S
B	ECN 89	NG	7/6/70	
A	ECN 294	BH	12/2/70	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030
scale N/A
material N/A
finish N/A

WAVETEK san diego, calif
by BOCHICHIO date 11-25-69 app.
title ASS'Y, BRACKET
model no. 740 dwg no. 0740-001 rev D

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